YOUR CONSTRUCTION AND OPERATING QRP SOURCEBOOK

# QRP Quarterly

Volume 61 Number 3
July 2020

Journal of the QRP Amateur Radio Club International

Gwen, NG3P introduces us to USB-C Power Delivery for QRP operation in the field

- Build the HT-1 Along With W8TEE
- A Tapped Toroid Replaces a Roller Inductor in KI4IO's Antenna Tuner
- Does Winding Toroids Frustrate You? K7WXW Feels Your Pain!
- *A QRP Classic—* Verticals Without Vertigo by W4RNL (SK)

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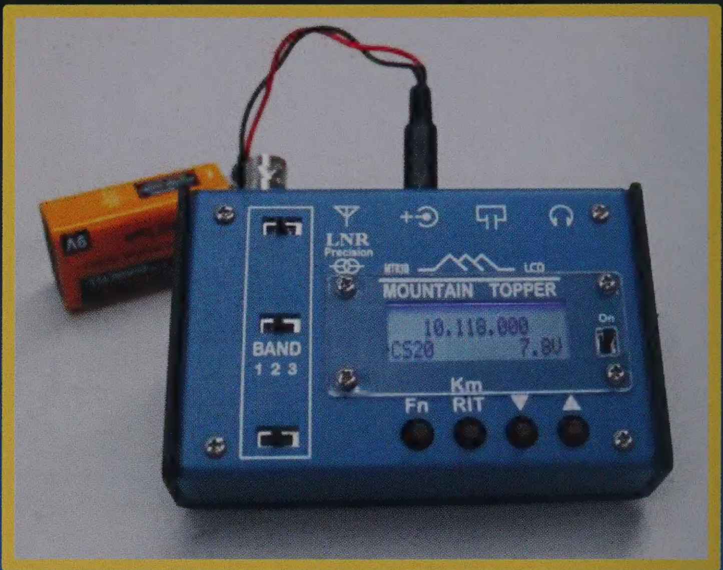

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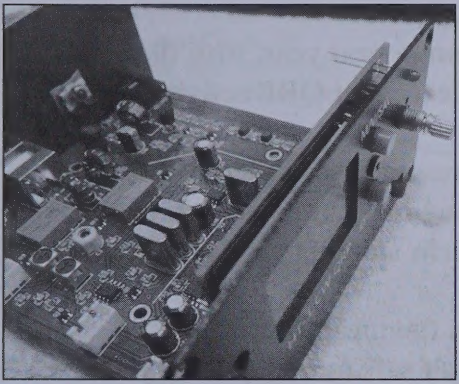

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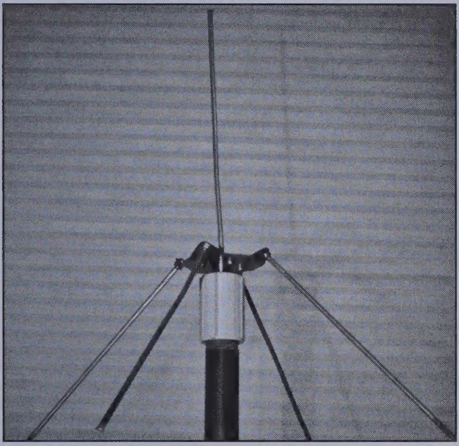

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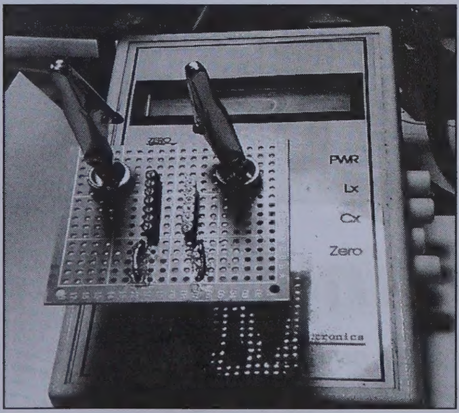

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**REMINDER:**

**QRP ARCI's 2020 Four Days in May (FDIM) was cancelled due to the COVID-19 outbreak and related public health measures.**

**The Hamvention® also was cancelled, along with many, many other conventions, hamfests, seminars, meetings, etc.**

**FDIM will resume next year, with the usual lineup of excellent QRP activities!**

**Some of the presentations scheduled for this year are being re-written as articles for *QRP Quarterly,* starting with this issue.**

**In the mean time...**
**Keep yourself safe and help keep your country well by following the guidelines of public health officials worldwide!**

**See you at FDIM 2021!**

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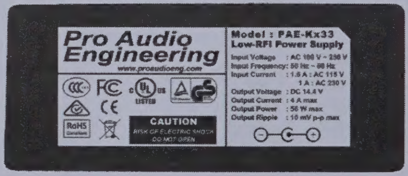

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# Letter from the Editor

Mike Malone—KD5KXF editor@qrparci.org

Well summer is here again, and that means hot weather in Texas. I always thought that it must be nice up there at ARRL Headquarters this time of year since they chose June for Field Day. Here in Texas, June is pretty sporty! As in Gatorade sporty! So many events and gatherings I would have attended this spring have been canceled due to Covid 19. We are fortunate that QRP contests are great "social distancing" events. With enough distance those contacts are DX for us! So, like many of you reading this—I am working from home, and taking the necessary precautions. I have to admit, I kind of enjoy wearing a mask into my local convenience store—I have to suppress the urge to yell "everyone on the floor, NOW!" It's all right though, I am just sick that way.

QRP ARCI has had some recent changes in board and presidency, and I want to thank those that have served in their positions. Thank you all for your service in the club and your work to make this pursuit a fun one. Dave NM0S is someone I always look forward to seeing at Ozarkcon, I applaud the choice made to make him President. We have a new Contest Manager, Paul K4FB. Paul was my roommate at my first FDIM. (Can you believe how long ago that was Paul?) Paul is a Flying Pig, and FPQRPI has a long standing tradition that QRP ARCI can now join in. No matter what happens—we blame Paul. Give it a try! I think you will like it too. Paul is pretty serious about contests. When he came to Dallas, TX on business, we presented him with a key to our city's restrooms. His only concern was whether he could come work the fox on my K2. We ate frozen pizza off the box it came in and worked the fox. Good times, so once again... another great addition.

Speaking of great additions, I hope you will enjoy this edition of the *QRP Quarterly*. I had a lot of contributions and it was great fun reading these articles and putting this together. I get a lot of credit about how good the *QQ* looks, but I will now reveal my secret to this. It is a fellow QRPist by the name of Gary Breed. He is who gets this thing assembled for print and does a wonderful job every issue. He also has to deal with my crazy submissions. Your editor is bad about doing things in BSD and Linux. Thanks Gary! With that said, we should thank my boss for his giving me a work box with Windows 10 and Windows Word. Actually... don't thank him. I am, errr, poaching on this machine. Since I am an intellectual equity partner, it is probably okay.

I am so thankful for this hobby, and the kits and components I have hoarded have been a genuine blessing in this covid crisis. May all of you stay safe and enjoy the hobby responsibly... as in be sure to eat, drink, and sleep occasionally. Also, if you are social distancing... please don't try to put up that new tower by yourself, or that large vertical near the powerline!

Until next time, may your antennas stay up, your SWR down, and your days be good.

*72 de KD5KXF*
*Mike Malone*
*Editor, QRP Quarterly*

# From the President

David Cripe—NM0S

president@qrparci.org

Greetings to everyone in the world of QRP. We mark this occasion with a transition of leadership, thanking Preston Douglas for his service to the QRP ARCI. I was blessed with the opportunity to step forward to lead this outstanding group, so I step into this role will full appreciation of the task at hand.

If you've been to Ozarkcon or FDIM, you've probably seen me. I'm David Cripe, call sign NM0S. I've been a ham for 39 years, currently employed at the big radio shop in Cedar Rapids, Iowa. Why am I doing this? Well, frankly, I just love radio. My house is full of radios. I design them all day long, and far too late into the night. My friends are hams. My kids are hams. I owe my career to ham radio—but that is a story for another day.

Even though I have worked on some high powered radio systems in the day job, I have always had a love for QRP. Ham Radio is an incredibly broad hobby, but if you look around, I believe the QRP guys are having the most fun of anybody. If you have been to our Four Days In May event, you'll know what I'm talking about. The designers, builders and operators of QRP gear combine the right mix of passion and amusement in what they do, and the result is the most possible enjoyment per dollar, per pound, and per cubic inch of radio gear. I'm proud to be a part of the fun.

The current year 2020 has proven a challenging year for the organizers of ham radio events, and that is true of QRP ARCI. We all were disappointed to have to cancel FDIM. But you have my assurance, that FDIM 2021 will be the best one yet!

Thanks to everyone for their support, and I look forward to working with everyone.

*73, Dave Cripe NM0S*
*President, QRP ARCI*

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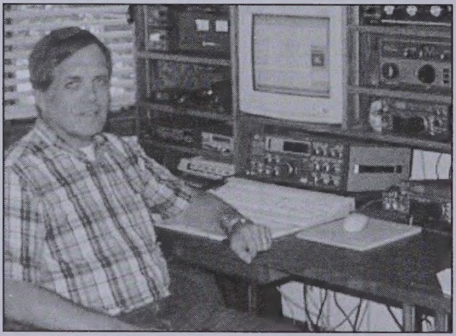
# QRP ARCI News

**Bill Kelsey Named Club Vice President**

QRP ARCI would like to announce that Bill Kelsey N8ET, has been approved by the QRP ARCI Board of Directors to be the new club Vice President effective July 1, 2020. Bill is a long time member of QRP ARCI and has been a contributor to the world of QRP for many years. He was voted into the QRP Hall of Fame in 2004 and is well known for his work with the GQRP group and founder of Kanga. Bill was first licensed in 1962 and is an avid sailor.

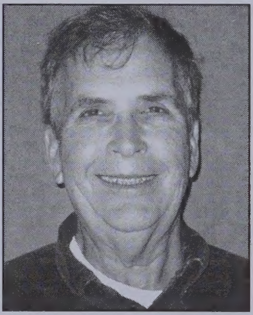
Kathy Bromley, WQ5T, has served the club as Vice President for over three years, and we thank her for her service.

**AA0ZZ Joins the Board of Directors**



The staff at QRP-ARCI would like to welcome our new board member. Craig Johnson AA0ZZ has accepted a position on the Board of Directors, for a term lasting three years. Craig is a widely known QRP enthusiast, and was featured on the cover of the July 2016 *QST* magazine along with his AA0ZZ 40m Direct Conversion Receiver, the ZZRX-40. Craig was also featured in the July/August issue of *QEX* with his "Programmable PLL (Si570) VFO for Amateur Radio Applications". QRP ARCI is very happy to welcome Craig to the board.

**Craig Behrens, NM4T (SK)**
*From Jim Stafford, W4QO:*



*Craig Behrens, NM4T*

It is with regret that I have to report that long time ham friend and QRP ARCI enthusiast, Craig William Behrens, NM4T, passed away at age 73 on February 27, 2020 in Madison, Alabama. He fought a courageous five year battle with GBM and Myasthenia Gravis. Craig was born on December 3, 1946 in Worcester, Massachusetts. He served four years in the U.S. Air Force stationed in Bangkok, Thailand. He received a B.S. from the The University of Alabama in Huntsville. He also attended Asbury Theological Seminary in Berea, Kentucky, fulfilling his passion for further theological study. His lifelong hobby of amateur radio endeared him to members of radio clubs in Alabama, Georgia, Tennessee and California. Scuba diving was also his active lifelong pursuit—he dove off the coast of 21 different islands.

Craig's activities in Amateur Radio are quite numerous and include:

- Longtime member of QRP ARCI #8137
- QRP ARCI Board of Directors, 2014
- Member of the North GA QRP club for many years
- Past editor of the *QRP Quarterly* including introduction of full color covers and historic 40th anniversary issues
- Wrote many articles, some for *QQ*, *QST*, and *CQ* magazine.
- Worked at QRP ARCI booths on many occasions
- Organized and manages the "Two Days in Huntsville" event for many years including forums at the Huntsville hamfest. TDiH included Mystery Antenna Contests, BBQ dinner on Monte Sano Mountain, and Buildathons with recruited celebrity judges such as Eric Swartz, Rex Harper, and Joe Eisenberg.
- QRP ARCI activation of K6JSS for Alabama with over 200 QSOs.
- Created Skunk Works QRP development

team for TenTec Rebel transceiver
- Member of the 2013 Buddies in the Caribbean DXpedition-St. Lucia
- CQ WW SSB Contest Team to Saint Kitts
- Presented forums at 2014 OzarkCon, various FDIM, and ARRL contentions
- Member of Alabama Contest Group with many QRP entries
- Past North Alabama DX Club president and newsletter editor
- Huntsville ARC leader of 40M station as part of many class 4A winners of 1st place in the USA.
- SOTA and POTA activist for many years
- Builder of many QRP kits including K1, K2, K3, P3 and others.
- Flying Pig #331 and NAQCC #5614

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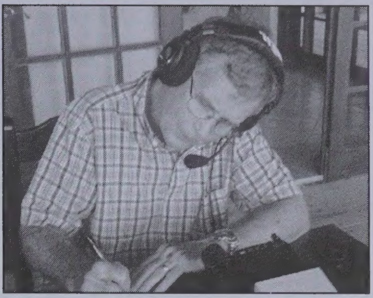

## K4FB to Manage QRP ARCI Contests

Our old FDIM buddy Paul Womble, K4FB, has agreed to be the new Contest Manager for QRP ARCI. Jeff Hetherington, VA3JFF, was the C.M. since 2004, and has offered to help Paul.

## The 2020 QRP-ARCI Spring QSO Party

*Brian Murrey, KB9BVN*

The Spring QSO Party was underway at 0000Z on April 11th, and it ran until 0600Z. Thanks to the efforts of QRP ARCI members Jim Stafford W4QO, Ron Stark KU7Y, and Brian Murrey KB9BVN the event got a big advertising boost covering the numerous QRP reflectors, QRZ and eHam, and just about anywhere we could find to mention it.

At the time of this writing, 60 logs have been reported on the wonderful website that QRP ARCI member Diz Gentzow W8DIZ created and runs for all QRP contesting that wants to use it. If you participated in the event and have not yet recorded your log and comments, please do so at once. The website is https://qrpcontest.com and is very easy to use.

This year the Spring QSO Party was converted from a 24 hour format to 6 hours. Several reasons for this exist, and it appears that the majority of those that have posted logs and comments enjoyed the 6 hours format. The best band this time was the 40m band, and then the 20m band. Conditions were up and down but contacts were being made.

Jack Reed WA7LNW made almost 80 contacts and left these comments: "K3 running 5 watts to a 40 meter inverted-V on 65 ft. tower, anchored to a sandstone cliff edge at 5,300 ft. elevation ASL. This HF remote overlooks the Virgin River and Zion National Park in southwestern Utah."

Jim Stafford W4QO made 64 contacts, with 53 of them being ARCI members. He was using his KX3, 80m Loop, and a 3 element Yagi on 20m.

Rick McGaver NK9G managed contacting 39 ARCI members and had this to say: "Nice to make some QRP Qs. I would rather go back to 24 or 36 hour format, but I understand lack of participation is a big factor in a longer format. I figured with the lockdown the band was going to be really hopping. Not!"

Jerry Scherkenbach N9AW contacted 41 ARCI members with his set up left these comments: "Had fun in the Spring QSO Party. Was hoping for more activity. Would like to see better hours for operation, some daytime into evening hours, not 7 pm to 1 am local. No propagation on 20M and up at current contest times."

John Harper AE5X worked the contest from TX and made contact with 27 ARCI Members: "I used the mcHF at 5 watts on battery power. Good to work familiar callsigns!"

Paul Womble operated from Florida, and had this to say after working 29 ARCI members: "Good amount of activity on 20m and 40m tonight. I worked several member numbers below 5000 and one 3 digit!"

Gerald Hertle WA9AGG was operating from the Hoosier state, he contacted 22 ARCI members, and had agreat time. Here are his comments: "My first ever QRP contest. I learned a lot about contesting with less than one watt and look forward for the next QRP contest."

Larry Makoski W2LJ worked from New Jersey and contacted 18 ARCI members in the time he was able to work the event. "That was a lot of fun! Only able to stay awake for a couple hours, but there was a decent amount of activity!"

Well tha's it in a nutshell. You can view all the log reports and the spoapbox comments at https://qrpcontest.com.

## 2020 Hoot Owl Sprint

*Paul Womble, K4FB*

Many thanks to everyone who participated in the 2020 Hoot Owl Sprint. Sixty-seven entries were reported at qrpcontest.com showing a significant increase in activity over the last few years!

In the Fixed category, Jim W4QO took the top spot with a score of 24,150 from his North Georgia QTH. Also in Georgia, John K4BAI finished in second with a score of 20,608. Rounding out the podium in third was Mike W3TS, running only 1 watt, with a score of 20,160.

The Field category was a change for 2020, replacing the previous field "5000 point bonus", with a separate category encouraging operating outside with temporary antennas. Five logs were received in this category by stations braving the elements and mosquitoes. Taking first place was Peter NN9K with a score of 6958. In second was Donald W2JEK operating "patio portable"with a score of 3500. Tom K4KAC with a score of 2646 finished in third. Congratulations to all!

Five stations reported running 1 watt or less. Mark NA4O and Bill K2EKM both were running 700 mW! Activity was good on 20m and 40m. Summertime QRN made 80m a challenge, however QSOs were reported on the band. Joe OK8GG and John AL7JK reported being on the air for the sprint but did not log any stations. Thanks for being there!

Thanks to Norm WA4ZXV for all the work to email out certificates and to Diz W8DIZ for providing qrpcontest.com for log submissions. Several stations noted this was their first QRP-ARCI contest in several years, or ever! No doubt the publicity by W4QO and KB9BVN helped get everyone on the air.

The next QRP ARCI contest will be the 2020 Summer Homebrew Sprint on July 12 from 2000Z to 2300Z. Check out all the rules at www.qrparci.org

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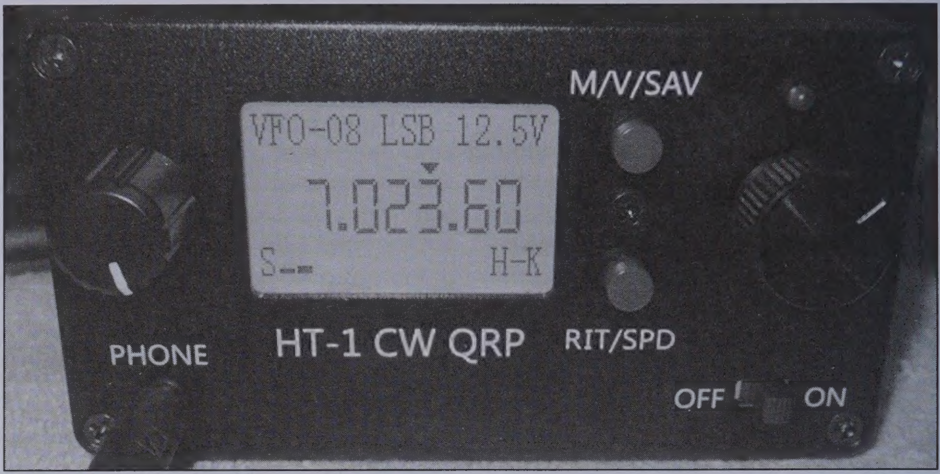
# Building the HT-1 Transceiver

Jack Purdum—W8TEE jjpurdum@yahoo.com



**The HT-1 transceiver from CRKits.**

**It's a sickness...**

If I see a new QRP rig, I just have to get one. That's the bad news. The good news is that most QRP rigs, at least those in kit form, are not that expensive. The HT-1 is 5W CW two-band transceiver for 20 and 40 meters. The transmitter covers 7.0-7.2 MHz and 14.0-14.3 MHz, but the receiver can tune approximately 6 MHz to 16 MHz, including SSB signals. The reason I was attracted to the HT-1 is because it's from the same company that produced the CRK-10A kit I built years ago. (It was one of the QRP rigs that Dennis Kidder, W6DQ and I added our VFO to, as described in our Arduino Projects for Amateur Radio book.) I remember being especially impressed with its receiver.

I got what I call a "semi-kit", in that all of the SMD parts are already mounted on the board. I'm building the kit right in the middle of the COVID-19 shutdown, so I have some time on my hands and this is a great diversion for me.

**Building the HT-1**

The first step is to download the assembly manual from the CRKits.com web site. There is also a video that augments the written assembly instructions. Watching the video before you start construction was a worthwhile time investment as it cleared up some initial questions I had while unpacking the kit.

**Getting Started**

The instructions are not the Heathkit variety where each step is explained in excruciating detail. For example, the manual starts with a single paragraph that ends up with you installing 25 parts. Fortunately, when combined with the printed list of the parts (you did print that out, didn't you?) it's pretty easy to figure out what's what. For example, it says to install "...trimmer capacitors C13 and C16..." as part of that paragraph-long directive. However, one of the them is yellow and the other is brown, and it specifies that on the parts list. In other cases, the parts are the only ones that agree with the silk screen (e.g., the tuned coils) on the PCB.

I am impressed with the board layout as some things, by design or not, are helpful while building. For example, the electrolytic capacitors are installed early in the building process (as part of that one paragraph, 25-part instruction). There are six electrolytic caps and, because their polarity is important, it is a common source of errors for the beginning kit builder. What is nice with this board is that, after installing all six caps, the builder can pick up the board to eye-level and look at the caps. Every cap should have the "gray stripe" that marks the negative lead facing them. If you don't see a gray stripe on each one of them, you messed up. (The instructions don't point that out, so make a note of it.)

For the most part, placement is easy as the silk screen also identifies the part. Using the silk screen combined with the photos of the board, make it simple to get most things in the right place...but not all. For example, the 2 and 3 pin header sockets are a little fuzzy as to their orientation on the board. This is important because the connectors are "keyed" with plastic ridges so they only fit into the pin socket one way. In Figure 1, you can see how the sockets must be mounted so the connector "key" fits in the correct way. The video shows such details much better than the written instructions. See:

https://www.youtube.com/watch?v=3N7Ezabt5kk&feature=youtu.be

If you have doubts about the placement of a part, study all the photos and look for one that shows the part of interest. If you take your time, you shouldn't have any problems.

As you can see in Figure 1, there are a number of parts that are placed on the board during the build process. (For $25 more, you can buy an assembled unit, but who wants to do that?) That "row of holes" on the right side of the board is for the display board which is also pre-assembled even when you buy the kit. Other than soldering an LED to the display board, it is completely assembled.

**Oh, no ... Toroids!**

I don't get it. Winding toroids sometimes scares builders, but it really shouldn't. I built one QRP single-band CW rig that had 12 toroids in it. This one has three... piece of cake! (Well, two toroids and one transformer.) I wind so many toroids that I have a custom built Toroid-Winder Holder, as seen in Figure 2. (I thought about getting a patent on it, but decided not to.) My custom holder is made from a chop stick that is secured in a drill press vice that I have in my office. If you have a Chinese restaurant near you, you can probably save the $2 it cost me to buy 24 chop sticks.

Before I start winding a toroid, I estimate the length of wire I'll need and cut the wire to that length. I then grab each end of the wire with a set of pliers and gently stretch it, making sure there are no loops or

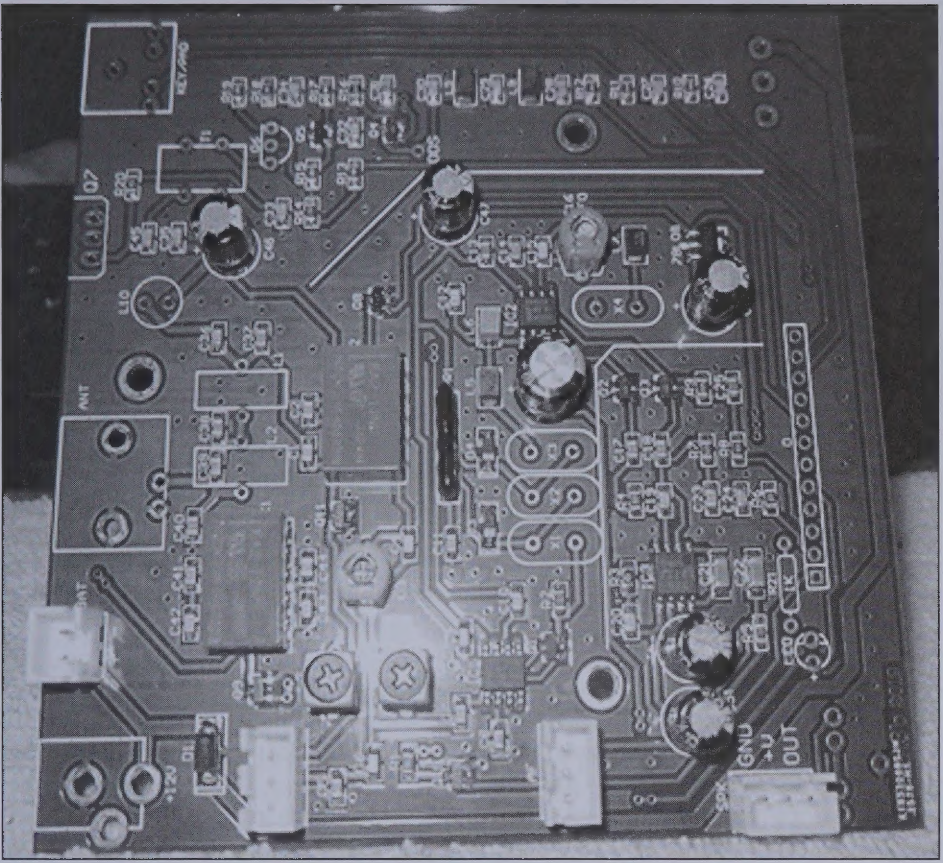


Figure 1—Pin socket orientation.

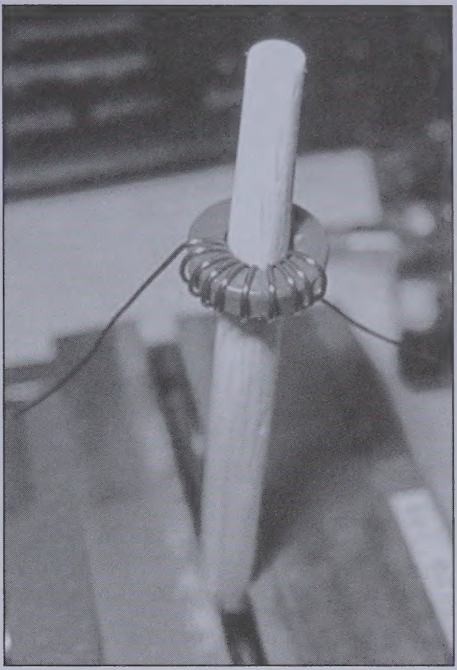


**Figure 2—Winding a 10-turn toroid on my custom Toroid-Winder Holder.**

kinks in it. The process also tames the wire a little so it doesn't want to roll back up on itself.

Each time you pass the wire through the center to the core, it counts as one turn. I then push the wire through for the next turn and pull the wire tight enough that it snugs down on the core. Repeat the process until you have the required windings in place. The toroid winding details are shown in Table 1.

The toroids in this kit are pretty simple to wind since there are relatively few turns on each one. The chop stick allows you keep the coil tight by simply pushing down on the core and snugging it down onto the chopstick. This has save me some frustrating moments when the phone rings in the middle of winding one. On toroids with more turns and counting turns seems imprecise, I snug the core down on the chop stick, grab my digital camera, take a picture, and count the turns on the picture. (Those of you who are laughing right now, this will seem less amusing when you're my age.)

| Part | Turns | Wire Length in inches (approx) |
|---|---|---|
| L1 | 10 | 8" |
| L2 | 12 | 9" |
| T1 | 8, 2 | 7", 3" |

**Table 1—Toroid winding data.**

When I'm done winding a toroid, I usually take a box cutter and scrape the enamel coating off the wire, taking care not to nick the wire. You could also abrade the wire with some sandpaper. Some builders prefer to just burn the enamel off with a blob of hot solder on the tip of the iron. That works and it does tin the leads, but to me it always smells like feet when I do it, hence the box cutter method. After soldering in place, always check the two solder pads for continuity. It should look like a dead short with a VTVM.

### More Stuff to Mount

After the toroids are soldered in place, the headphone jack and power switch are mounted to the main PCB. Note that these end up feeding through the front faceplate and are mounted to the underside of the PCB. Make sure they are mounted square with the PCB so they fit properly with the faceplate. Next the vertical display board is soldered in place. Make sure there is no gap between the main PCB and the display board.

Next is the mounting of the IRF510 power transistor. This transistor is a pretty rugged device that has been used in other QRP rigs (e.g., the µBITX). I screwed this up. It must be mounted using its insulator pad and small plastic bushing that electrically isolates the transistor from ground, but allows it to dissipate heat to the back plane. Loosely fit the black bolt through the back plane and, when all of the other back plane connectors are in place, tighten the bolt to the back plane. I took the lock washer and nut and threaded them onto the BNC connector to hold things in place.

Without knowing it, I pinched the insulating pad enough to short the IRF510 to GND. For reasons I can't explain, once the bolt was properly secured, the rig ran perfectly. Why the magic white smoke didn't escape is a puzzle to me.

Now locate the remaining small LED and thread it into the upper-right corner of the display board. The longer (+) LED lead should be closest to the top of the display board. Do not solder in place yet. Peel off the protective film from the faceplate. (The

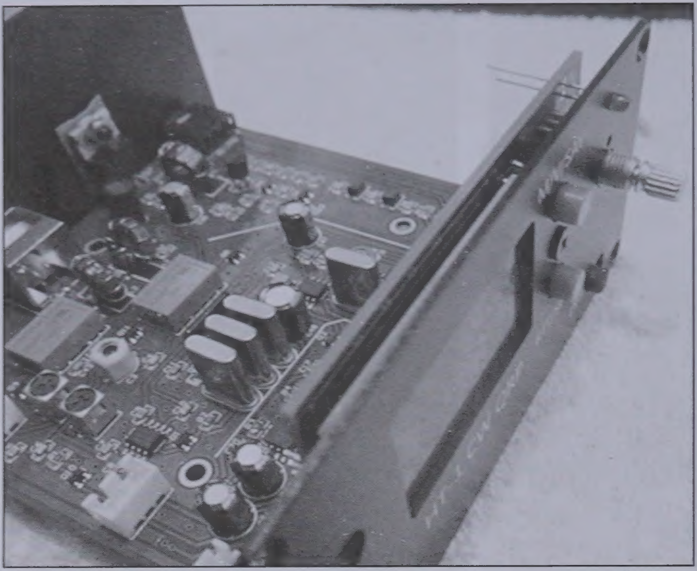


Figure 3—The LED and front panel placement.

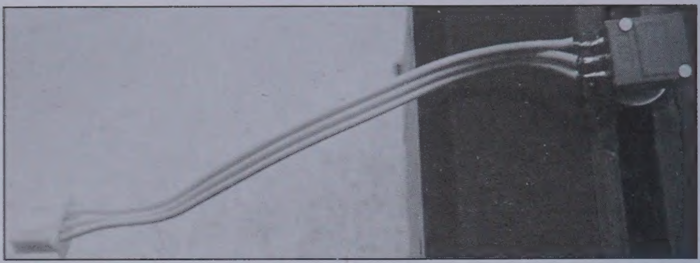


Figure 4—Soldering the "keyed" connector to the AF pot.

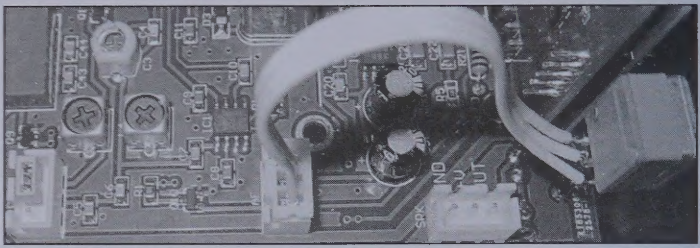


Figure 5—Connecting the cable and installing the jumper.

film has a small blue tab that can be used to pull off the film.) Also, remove the nut and washers from the encoder. Now take the front panel and fit it to the display PCB, aligning all of the connectors/switches in their openings, paying particular attention to the headphone jack. It should sit flush with the front panel. (The fit-and-finish of the parts is very good.) Finally, take the small black screw that remains and thread it between the two push buttons and tighten to secure the front panel to the display board.

Now you can solder the LED to the display board. Before soldering, slide the LED into the position that you like best. I want the LED to protrude a little so I can see it without being directly in front of the rig. Solder the LED in place and clip the leads. You can also thread the washer and nut onto the encoder and tighten.

The gain control needs to be attached to the front panel and the main PCB via a 3 conductor cable. Because the cable uses a "keyed" connector, you need to pay attention to the orientation of the cable relative to the pot. In Figure 4, you can see the two plastic "keys" (i.e., "bumps") on the left end of the cable and how those leads need to be connected to the AF pot. After you have soldered the cable to the connector, connect the AF socket on the main PCB and also place the yellow header jumper plug in the RF socket as seen in Figure 5. Notice that the jumper is between the two inner-most pins.

You should now mount the three brass standoffs onto the main PCB using a spring washer and bolt mount from beneath the main PCB. These standoffs are used to secure the internal battery for the transceiver. Even if you don't expect to use the internal battery, I would still mount the board in the event you change your mind later on. Otherwise, if you're at all like me, the battery board will get lost.

That's it... the kit's built. Alignment is three simple adjustments which are explained in the assembly manual. Alignment is little more than setting three adjustment screws (visible to the right of the relay in Figure 5). No special test equipment is required. The manual also suggests additional mods that can be made, if you're so inclined.

## Using the HT-1

The User's Manual does a good job of explaining the many features of the HT-1. It supports RIT/XIT, up to 16 stored frequencies, keyer or straight key, variable tuning increment, S meter, and a backlight mode. If you have the backlight mode set to OFF, the backlight is always off. Set it to ON, and it is always on. A third option is AUTO, which leaves the backlight on for about 10 seconds after any frequency adjustment and then turn itself off. This helps to save battery power.

The HT-1 has a feature called Auto Scan Mode (ASM) than I have not seen in other QRP rigs. If you are in the MEM(ory) mode and activate the ASM, it scans the 16 frequencies you have stored in memory. If you are in the VFO mode, you can scan up or down the band from its current frequency using the current increment value.

The many options take some time to learn, not because they're difficult, but only because there are a lot of features available, but activate using a pretty simple button system. An hour with the rig and everything quickly becomes second nature.

## Conclusion

The receiver is very sensitive...even better than the CRK-10A I remember. On my second 40M CQ, I got a guy in LA who gave me an honest 559. If you're a QRP fan, you could care less about that middle number. It's the first and last digits that count! The semi-kit costs $150 which includes shipping or $175 for the assembled/aligned HT-1. I like the HT-1 and plan on taking it into the field when the weather gets a little nicer. The fact that it is a two-band rig is a real plus, as it gives me some options I don't have with some of my other QRP rigs.

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*— QRP means "Doing the most with the least" —*

# Microphone Conversion

Don Cantrell—ND6T

nd6t@velotech.net

Most of the current QRP designs for 'phone transceivers utilize electret microphones. They are cheap, reliable, and have excellent performance. Often they are not provided as part of the kit and it is the builder's responsibility to provide it.

Electret elements have very flat response and high output. They employ an internal FET pre-amp within the compact package and require a power source and blocking capacitor from the transceiver. Kits like the BITX, Epiphyte, Survivor, and SlobBucket designed for these and are scaled for the electret signal levels and impedance range.

### Microphone Housing

Many operators, especially those backpacking, need small and light equipment. These often choose to place the element in a fountain pen or other small tube and then add a push-button switch for the Push-To-Talk. Others, especially contesters, prefer the boom microphones on a headset. Those are common and are frequently found in the "Dollar Store" or "Pound Shop" emporiums and work very well.

For my own use, since I mostly use CW and appreciate a clear desk top, I prefer the hand-held microphone since I can hang it up away from the desk top until the time comes to use it. Since I like to purchase junque from the swap meets that I visit, old CB microphones are often available in bulk by the box and these are comfortable for me. The Push-To-Talk (PTT) switch is built in, there is a hanger button on the back so that I can place it in a suitable holder (like a magnetic one that clamps to the side of a radio cabinet or, in my case, a power supply) and a nice coiled cord that retracts itself out of the way.

### Electret Conversion

Keeping it simple, I have often chosen to just replace the dynamic microphone element with an electret element. The little electret element fits nicely in a rubber grommet. That helps isolate it from the noises of the user handling the microphone and the noise of the PTT lever. The flexibility of the grommet holds it in position without glue.

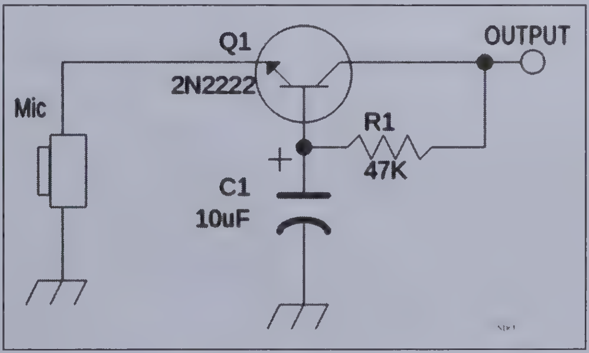
**CB microphones are easy to find bargains at swapmeets!**

After removing the dynamic element from the microphone shell I insert a rubber plug with a hole drilled in the center for the grommet. I can usually find one that just jams into the sleeve that held the old element. This blocks the hole and backs up the windscreen, maintaining the original acoustic configuration as much as possible.

### Dynamic Conversion

It is almost as easy to keep the original dynamic element and add a pre-amplifier. I came up with a design that uses just three parts. That qualifies as "simple" doesn't it? Just a few pennies in cost but I would assume that even the most meager of junk boxes already have these parts. No critical values.

The pre-amp is a simple common-base configuration. The microphone element connects to the emitter of a general purpose NPN transistor (2N3904, 2N2222, 2N4401, etc.) The other side of the microphone element connects to the common return (and probably the shield of the cord). The collector of that transistor connects to the wire that was where the emitter is now connected and is the output. Also connected to the output (and collector) is a biasing resistor that connects to the base. Since no significant power is dissipated it can be any size and the resistance value is not very critical, either. The base also connects through a 10 uF capacitor to the common return. The working voltage of the capacitor should be greater than the DC voltage applied to the microphone (usually 8 volts) and can be most any dielectric. Values between 5 uF and 15 uF will work just fine. If it is polarized (like an electrolytic or tantalum) then observe the polarity.



**This simple preamp has just three parts, using power from the rig.**

A common-base amplifier has a low input impedance and a high output impedance. This circuit adjusts to both quite efficiently and produces a very pleasant audio without adjustment.

### Construction

With just 3 parts, a printed circuit board is hardly necessary unless you are using SMD components. Most of the parts simply solder to the PTT switch. For those that want to use the SMD parts, a hand-carved board takes little room and makes for a clean installation.

### Results

I use both the electret and dynamic conversions interchangeably without gain adjustment on several BITX40s, my BITX60, a uBITX, an Epiphyte 2, an Epiphyte 3, and two of KD1JV's SlopBucket II rigs. The latter has been my primary SSB transceiver for more than 6 months now and the audio reports have been sterling. The dynamic microphones always get the best comments, especially from those infamous audio critics. What better confirmation!

*—de ND6T*

# No Roller Inductor, No Problem!

Jerry Wolczanski—KI4IO jerrywolczanski@earthlink.net

I was slated to give a talk at FDIM 2020 about "Making an Antenna Coupler". As a part of that talk, I was planning to touch on the construction of a tapped toroid inductor which I've successfully used in lieu of an expensive roller inductor. This article will not discuss antenna coupler construction, but rather it will only speak to the construction of an inductor used in an antenna coupler. Using a tapped toroid is not an original idea, but rather stems from an article entitled "A Balanced QRP Transmatch" by ARRL Lab Engineer Zachary Lau, W1VT. The original article appeared in the 1990 *ARRL Handbook*, Chapter 34.

Figure 1 is a front view of toroid used in one of my prototype antenna couplers. The Inductance is adjusted by the use of the shorting clip. In this unit the inductance varied from 0.156 uH (tap #1) to 6.68 uH (tap #25).

The banana jacks are used, with banana plug jumpers, to move the inductor to either the high-Z or low-Z side of the tuning capacitors. The beauty of a roller inductor is the almost infinite variability in the inductance "steps". Was this inductor sufficient in that respect? I'll address that a bit later.

### A Tapped Toroid

Zachary Lau chose a rather large T200-6 toroid from Amidon, now priced at $8.00. I also used this same size core which, in my application, has proved to provide just enough inductance (max. 7 uH or so) in my open-wire line tuner. Amidon also sells a 3" (T300-6) core, but it costs $27. If more inductance is needed, I'd be inclined to stack a pair of the 2 inch cores.

### Wire Size

I bought #14, insulated, solid, THHN wire from the hardware store in a 50' roll. I stripped the insulation off an approximate 7-foot length and wound the bare wire as tight as I could on the T200 core. I have been able to get 25 or 26 turns of the #14 bare wire on the core.

I then cut a number of 2" pieces of that same wire and soldered the taps. See the photo in Figure 2. There is nothing difficult here—it's just tedious. What else do you have to do while "self-isolating" at home?

Straighten out the wires as best you can and then count the number of spaces between the turns that are needed. Divide 360° by the number of spaces. In one of my coil, that came out to 13.8° between the coil turns.

### Your Protractor!

Of course, you still have your protractor from school, right? With the protractor and the diameter of the coil (my diameter was about 58 mm) you can locate the coil tap holes. Draw your hole template. This will be placed over your panel material to help mark the hole locations. Figure 3 is one from my last toroid.

When you are satisfied, this will be overlaid atop your panel or what-ever you are using. Drill bit size was 3/32". Don't forget, there will be one "inside" turn.

Straighten out the wires and insert them into the holes from the backside. This can be a little challenging—tilt the completed core and start that way.

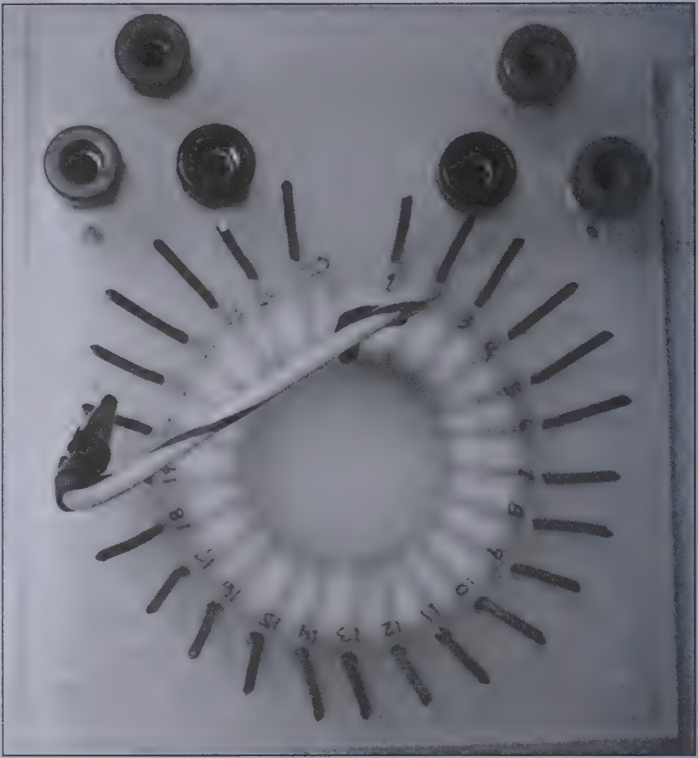


Figure 1—The completed assembly with the tapped toroid.

When you're done, it should look like the back-side view (Figure 4) of the core pushed firmly into the holes. This is a good time to make sure the turns are not touching each other.

The front-side wires can be trimmed and a shorting flexible wire jumper can be installed. I used a few layers of heat-shrink tubing to buttress the two joints, one where the jumper is attached to the clip, and the other where the jumper is attached to the inner wire.

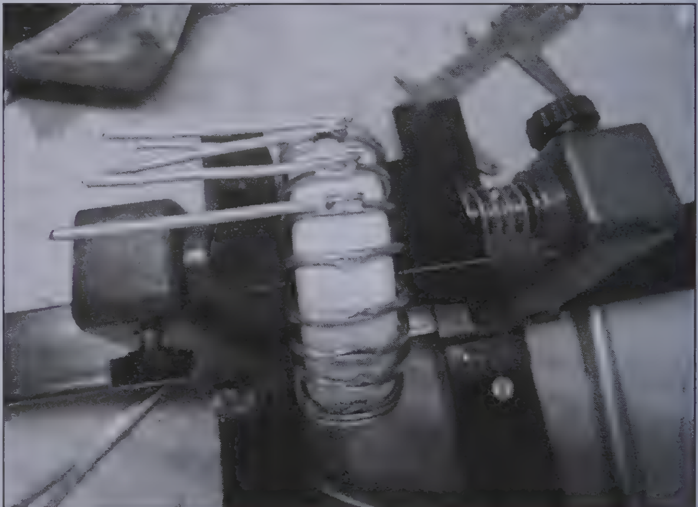


Figure 2—The taps are short wires soldered to the windings.

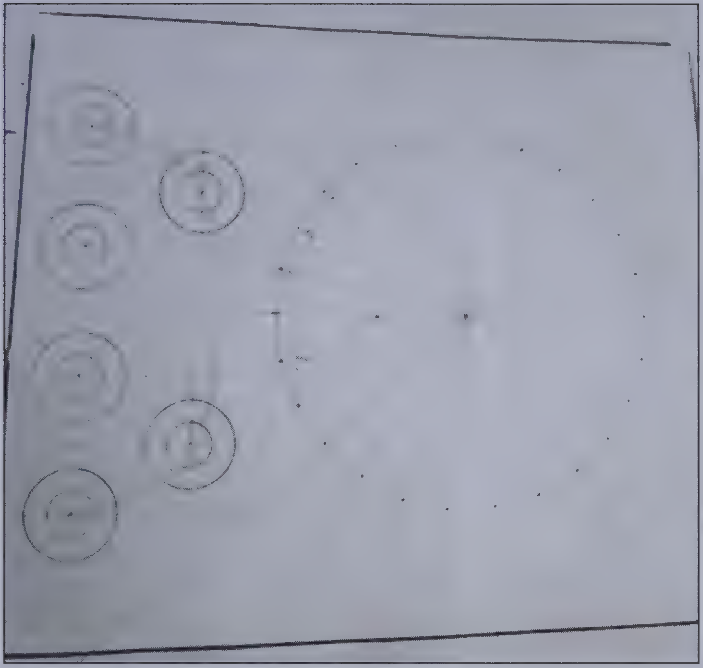


**Figure 3—Tap locations laid oaut with a protractor.**

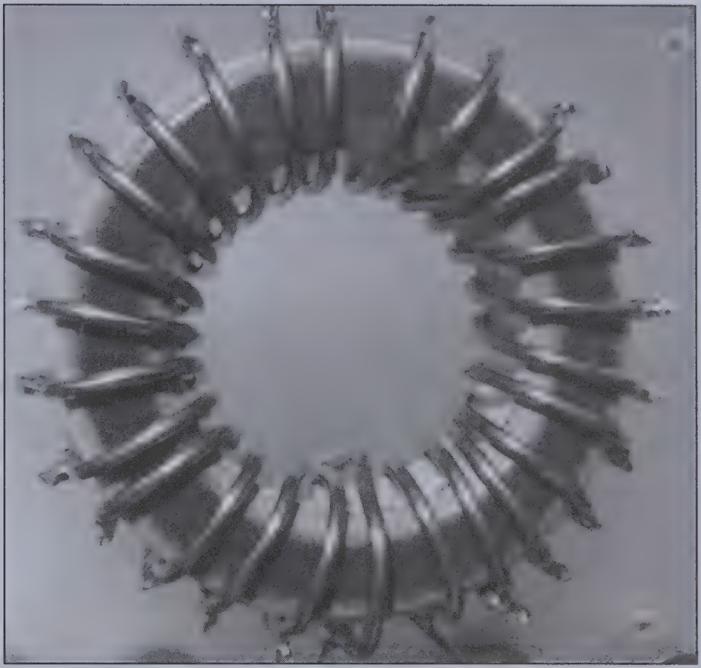


**Figure 4—Tapinstallation completed.**

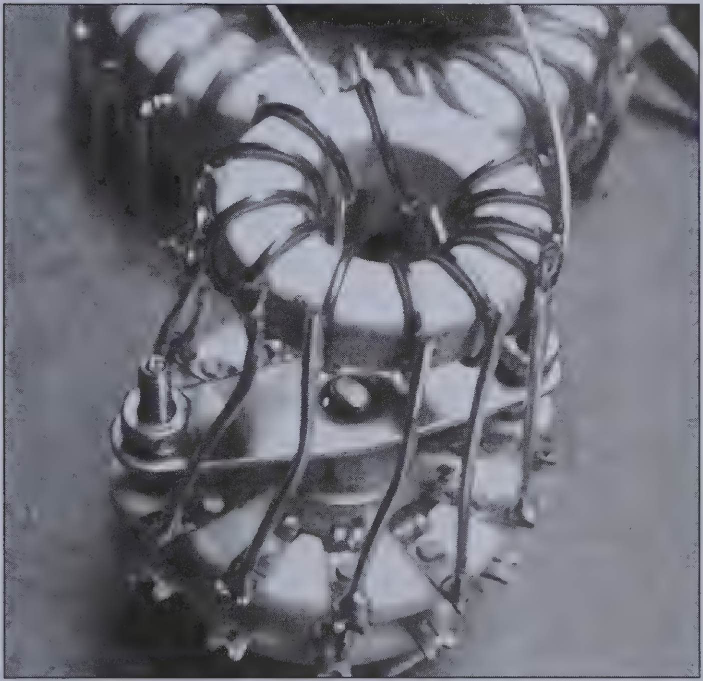


**Figure 5—A smaller fine tuning coil.**

**Coarse vs. Fine Adjustment**

Was the inductance gradation between turns sufficient for use in an antenna coupler? Probably yes, but I think much depends on the design of the coupler. In the case of one coupler I made, I constructed a "fine-tuning" coil which was put in series with the large inductor. It was a T80-6 core with 12 tapped turns, shown in Figure 5.

**Is Fine-Tuning Necessary?**

These couplers are so simple, with just 2 or 3 parts, it makes sense to build a mock-up and take it for a test drive before committing to a final assembly.

I use home-brew SWR meters that are not calibrated, so I tend to make coupler adjustments to a near-perfect (1;1 SWR) match—yet on one design, a true balanced coupler, the rather coarse tuning provided by just the main coil was quite sufficient. On the higher bands, the coil gradation becomes "finer" as more turns are shorted out... exactly what was needed.

**Conclusion**

Obviously this article is not about tuners per se, just the one component, the inductor. For tuners, generally speaking, low-Z loads can stress the inductor, and high-Z loads may stress the capacitor.

I'm looking forward to talking at FDIM 2021 about making an antenna coupler! I've included a photo (below) of the front panel of a coupler I made. The front panel is painted plywood. It's an L-network, the coarse and fine tuning are on the right. The capacitor tuning is the big dial, and to the left is the SWR meter, sensitivity pot, and forward/reflected switch.

Enjoy! See you at FDIM 2021

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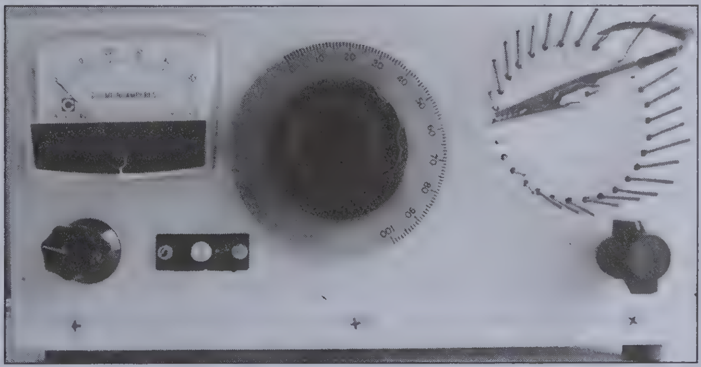

# QRP/DMR Handheld Ground Plane Antenna

Bob Thompson—K5RWT thompo@sbcglobal.net

Digital Mobile Radio (DMR) is a low power digital voice mode for hams. Repeaters for DMR are found in the 147/220/445 MHz bands. Hams rely on repeater. Hotspots provide hams independence, but can be expensive when you are just beginning to work VHF/UHF, so it is essential to reach a repeater if you can. This antenna can help.

Many DMR handheld radios depend upon rubber ducky antennas. These small vertical antennas are limited in their ability to reach marginal repeaters and maintain a connection. A ground plane antenna may provide the ability to talk to repeaters that have previously given unreliable results. But a ground plane on a handheld is likely to poke you in the eye or ear. In the shack you have the option of erecting an antenna connected to the handheld by coax.

A ground plane antenna for these bands are small, with radials measuring 19" (147 MHz); 12" (220 MHz); and 6.5" (445 MHz). Imagine erecting a tower for a 6.5" antenna. Fortunately, they do not require tower heights. The antenna I will show you here sits in my shack on a 2-foot perch. It took more time to mentally layout this antenna than it took to build it.

Using the pictures as a guide, you should be able to build one for any of the three bands in an hour or less, once the needed parts are acquired. The most difficult part to acquire will be the coax cable, with an SMA connector on one end and a PL-259 or BNC on the other.

The coax itself can be 316, RG-8, etc. Coax length is entirely up to you. A 3-foot length will allow the handheld to lay flat on the table at the base if the antenna. Six, ten- and 15-foot lengths give you more mobility in where you place the antenna. I found coax cables with appropriate fittings on both Amazon and eBay, and I am sure they are available from other sources, as well.

Construction of the antenna is straightforward, once the materials are collected. Many of you will have materials you can use in your junk box. Here is the list of materials:

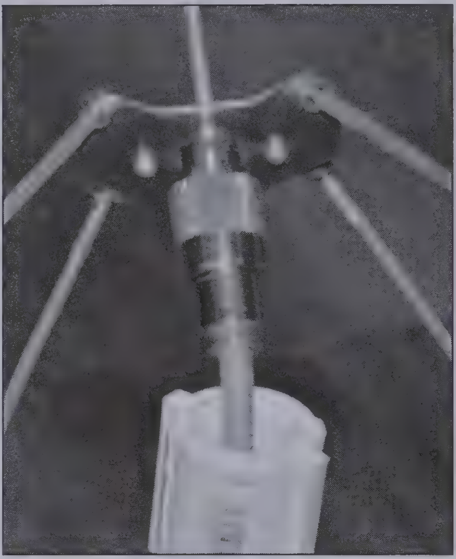

**Figure 1—A PL259 plugs right into the 1/2" threaded coupler (sprinkler 24" riser).**

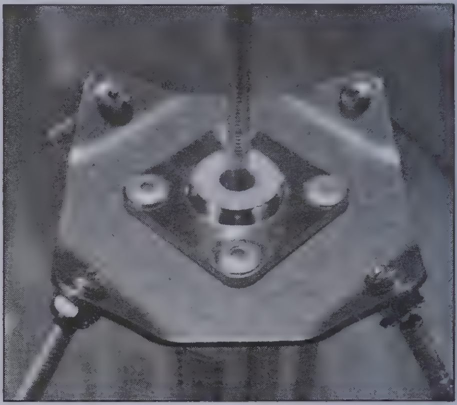

**Figure 2—This is a ground plane base plate from another antenna. It shows how easy it is to bend up the corners of a 2" X 2" piece of flat aluminum.**

- 2" square aluminum plate, 1/8" thick—Bend the corners up 45 degrees to mount the 4 radials (I used the base of an EE-3 "Y" Band Antenna)
- 5 pieces of 1/8" aluminum tube (Hobby Shop 12" lengths in packages of 3 tubes each)
- (5) 4-40 machine screws 1/2" long, with nylon lock nuts
- SO-239 socket for center of antenna
- Coax cable with SMA female and PL-259 connectors, length of your choice.
- 24 in. sprinkler system riser (1/2" PVC pipe)
- 1/2" PVC threaded coupler
- 1/2" floor flange (metal or PVC)

**Tools needed:**

- Small vise (to bend up corners of aluminum plate)
- 4-40 tapered tap (tap ends of 1/8" tubes)
- Small screwdriver and pliers (to install

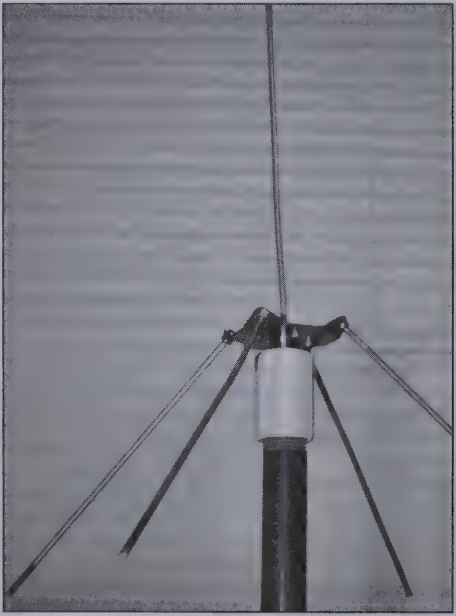

**Figure 3—Here is the antenna assembled with the coax going through the 1/2" PVC pipe**

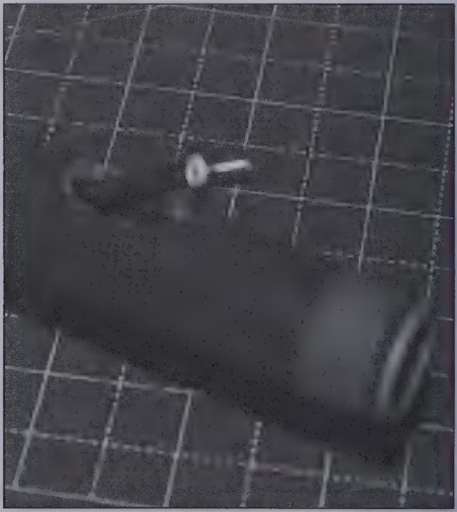

**Figure 4—Coax SMA connector sticking out of antenna mast. I used 24" sprinkler riser pipe because it was already threaded on both ends. Add more riser pipe and threaded couplers to extend the mast**

screws)
- Drill and 3/8" bit (for hole in bottom of PVC riser); an 1/8" bit for corners on the base plate and a 5/8" hole for the SO-239 =installation.
- Small forceps (to grab SMA connector and pull it through hole in side of riser pipe)
- A small Bible of your choice, for mental strength after dropping the last tiny nut on the floor during construction...

The last item is essential for me, as I have Neuropathy in my hands and have lost all feeling in my fingers, so everything I pick up falls on the floor at least once during construction. Usually, about midway through a project, the dog gets tired of being hit by flying materials and finds a place to hide under the bed.

This project is an ideal early activity for newbies to ham radio. With a little help gathering the needed materials, they can materially improve the range of their 2-meter handheld radio.

The last activity in this project is adjusting the lengths of the radiator and radials to the frequency of the repeater of your choice. This is accomplished by slowly shortening the lengths of the five rods until you achieve an SWR of 1:1 (or very close to that ratio). The radials can be cut to 6.5" for general purpose 445 MHz band; 12-5/8" for the 220 MHz band and 19" for the 2-meter (147MHz) band. I got an SWR of 1.1:1 without having to modify the rods at all.

There is a lot of latitude allowed in this project, both in the materials used and the construction methods applied. Have a great time making this antenna!

*—73 Bob K5RWT*

*Note:* A plan for a similar simple 2 meter ground plane antenna can be found in the *ARRL Handbook* in the UHF/VHF Antenna section.

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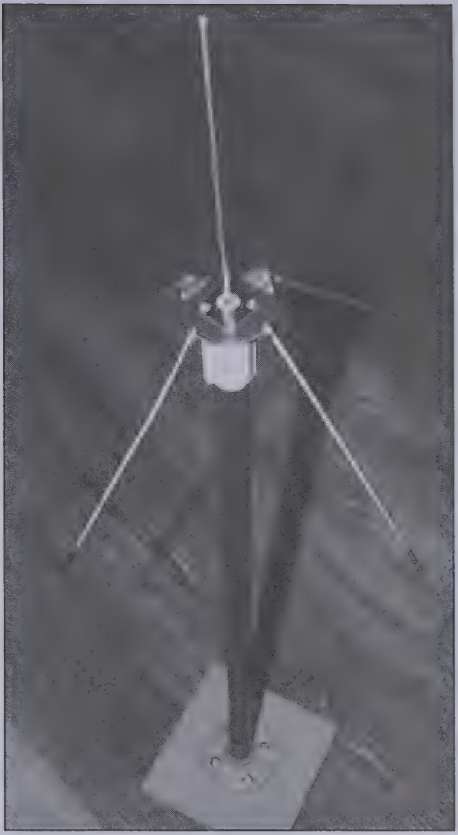

**Figure 5—The antenna looks like a model of a large antenna, but it works as well as any that will sit on your desk or stand outside on an extended mast.**

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# High-Rise Condo, Conquered

Gary Altman—K4NNK

Here I describe my most recent successful emission of 5 watts RF from my condo balcony while trapped inside due to the coronavirus pandemic. Today, within a 15-minute period I made contacts on 20M with stations in ME (K1JB), MA (K1BG), and CT (W1RM). I used two ten-foot telescoping plastic poles (Kite Garden) to suspend the radiating portion of a random wire antenna off of my balcony (Versa-Tenna™ by K7BHB).

It helps to be on the 26th floor, and yes, I am an electronics genius...

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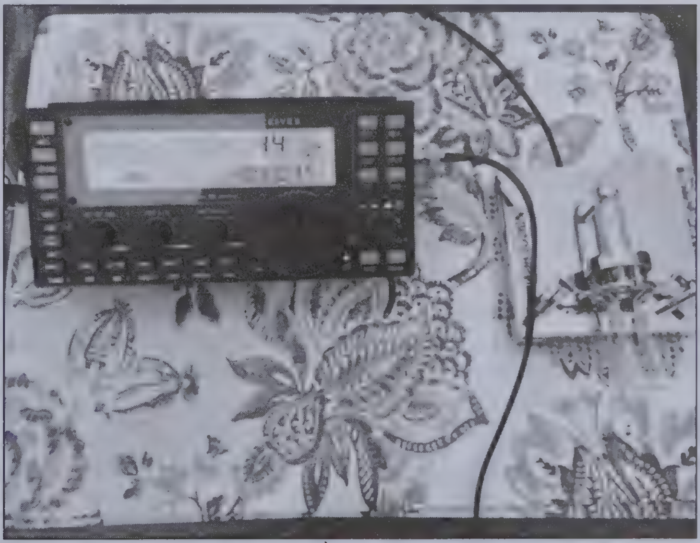
**The antenna (and the view from the 26th floor).**



**The K4NNK station.**

# A Different Power Source for Field Operating

Gwen Patton—NG3P www.ng3p.com

We're coming up on a confluence of two things: Nice weather, and relaxing of the Covid-19 lockdowns in much of the United States. This means more hams leaving their home shacks and taking their operating to the field. For some, this means climbing mountains and doing SOTA activations. For others, this means hiking on trails, and doing POTA activations. For yet others, this means gearing up for Field Day, or doing HF Pack operating, with a manpack station on their back. But no matter what they actually choose to do in the field and why, all of them have a similar need—*They need to power their gear*.

This can be a really complex issue. It has a lot of factors, like what radio the person plans to use, what its power requirements are, how many watts do they want to transmit with, how much does the radio draw during receive, will they have access to mains current at any point, if not, will they have gear to recharge their power source, will they be on foot, are they operating from a vehicle... the list goes on and on. But again, there's a need that intersects all of these issues.

They need the power source to be as flexible as possible, and to provide the maximum in available power for as long as possible, but as small and lightweight as practical.

When you're getting to your operating position by backpacking, every ounce and every cubic inch counts. So you want your power source to be small and light, yet you need it to provide enough power to fulfill your goal.

The default position seems to be: figure out how much juice you'll need for the duty cycle you expect, the power consumption your equipment will require, how much weight you can carry for the requisite distance, and what you can do to replenish that power in the field if you have to. It pretty much falls to: carry a lead-acid gel-cell, or a lithium-ion source with similar storage capability. If possible, carry some means of charging it, which usually means "solar panel'.

A lead-acid gel-cell with 5-10 amp-hours (Ah) of available juice is fairly inexpensive, between $2.00-$3.50 per Ah (Amazon prices) depending on brand and what the seller says it's for. Some use cases have higher price points, because it's a more-or-less "elite" use case. You can get a lead-acid 12V 9Ah gel-cell for around $25. But lead-acid batteries are heavy and bulky. If you plan to charge one in the field, it requires a special charger, or your charging device needs to have an output suitable for charging lead-acid batteries. They have a limited lifespan, and can be damaged or destroyed by drawing their voltage down too far before recharging, requiring replacement. Then you have a hazardous material to clean up, as your typical trash service won't take them. They're cheap, but can be a hassle. If you're willing to accept the hassle, though, you can get them very inexpensively.

Some radios, such as the Elecraft KX3, can be upgraded with an internal battery tray. The recommended battery for it is a set of Nickel-Metal Hydride AA cells. The rig will charge them, but ONLY NiMH batteries, the charging process is slow, and if you draw the batteries down too far, may damage the batteries so they no longer take a charge. They're lighter than lead-acid, but provide less power, and have special charging needs.

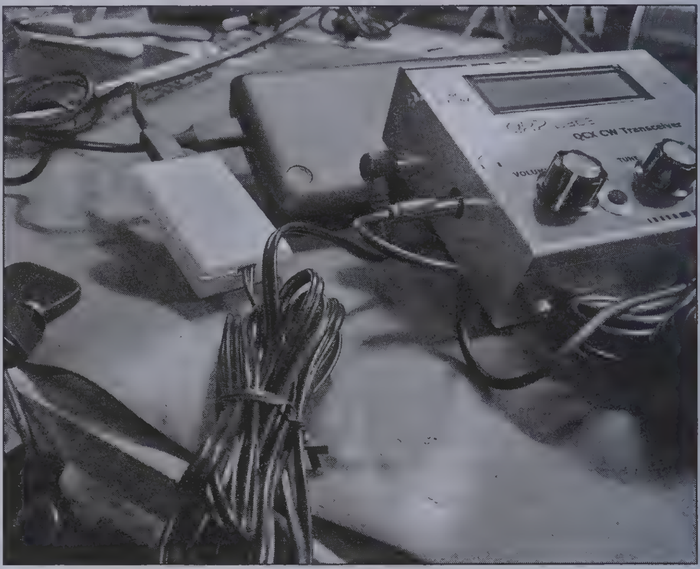


**Photo 1—Smart Cable connected to PD supply and QCX transceiver.**

Lithium-ion batteries tend to be lightweight, have a fairly high efficiency, and while more expensive, have a longer lifespan, requiring replacement less often. But they require a special charger, can take a long time to charge, and are considered to be a very hazardous material. Lithium-ion batteries have been known to explode or catch fire while charging, while in use, or following some kind of damage from incidental accidents, such as dropping. There are heavy restrictions on shipping them, and over a certain size cannot be taken on an airplane in carry-on baggage. The best chemistry for lithium batteries are the relatively recent Lithium Iron Phosphate (LiFePO4) variety. They're lighter, have an even longer useful lifespan, can be drawn down further without damage, and the chemistry isn't as explosive or prone to fire as other lithium-based cells. But they're expensive, running $8-12 per amp-hour.

The least expensive brand I know of are Talentcell brand. They even have small battery packs, at minimum 12v at around 3A, but some models having 9v and even 5v USB outputs. The 12v and 9v are coaxial jacks, and the units have power switches, power level indicators, and can be charged while in operation. My only complaint about these devices is that they're single-taskers—they are designed for a limited set of tasks, such as running LED lighting, or IP cameras.

What I had in mind was something of a multi-tasker. Something you could use for powering ham radios, or perhaps other gear as well. I've been looking at the little USB power banks for years, wishing there was a way to operate ham radios from them, but the power and voltage available on them was too low. But now, there's USB-C, and a new protocol for output power on USB-C, the Power Delivery standard.

PD is a handshaking protocol, whereby a device will communicate with a power delivery device and tell it how much power it needs to operate. PD can provide a whole host of values, from 5v at 50mA, to 20v at 5A, with reasonable steps between. It can specify a range of acceptable values, in case the supply device doesn't support the precise value required, but DOES provide something close. The key to the whole thing is a small circuit called a "sink". There are a number of them becoming popular online.

The "PD Buddy Sink" by Clara Hobbs is the first I encountered, on the maker site Tindie. It's a board a little smaller than an inch on a side, with a USB-C socket on one side, and either bare solder pads or screw terminals on the other. To specify the power setting, you connect to the board via a terminal program such as PuTTY over the USB-C connection, and issue the appropriate commands. Then you can write the result to the internal memory of the board and reboot it. The board will retain the setting until you change it. Another board, the ZY12PDN "Type-C USB-C PD2.0 3.0 to DC USB decoy fast charge trigger Poll detector 100W MA", as named on Amazon, is very similar, but instead will cycle between available values when a button is pressed. It's a slightly smaller and less expensive board than the PD Buddy Sink. The Buddy Sink costs $30 on Tindie, while the ZY12PDN costs between $13-18 on Amazon, depending on configuration.

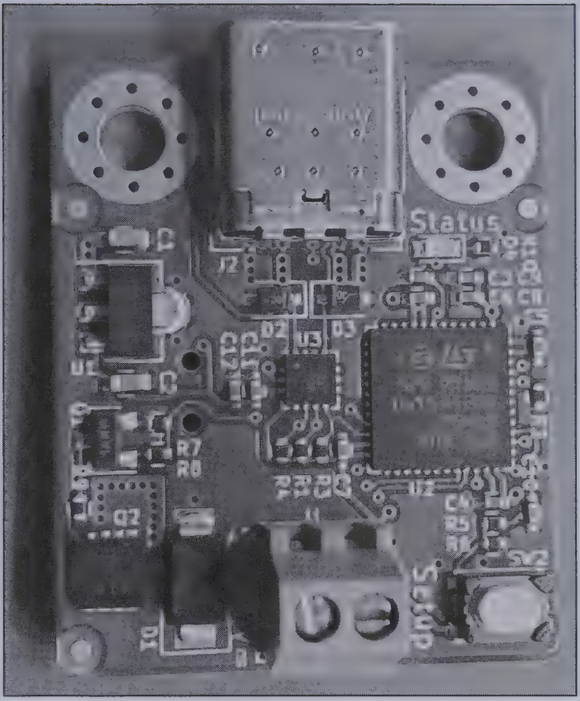


**Photo 2—PD Buddy Sink by Clara Hobbs.**

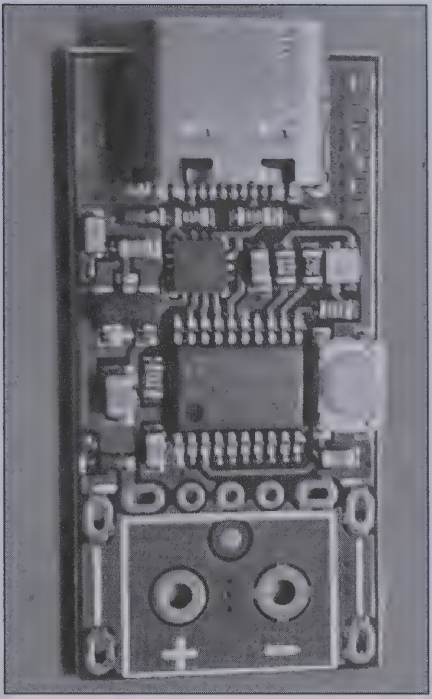


**Photo 3—ZY12PDN Board–Amazon.**

There is a Thingiverse project for a 3d printed case for the PD Buddy Sink in two configurations, one to accomodate a simple wire going to the output pads, and another where a pair of Anderson Power Pole connectors are incorporated into the case, allowing it to be connected to any device that supports Power Poles. But the first one I built, I used a small project box, and ran a two-conductor wire into the end opposite the USB-C connector. I thinned the lid directly over the LED power light, so I could see when the board is on and responding. Eventually, I'll put a small hole over the board's reset button, so I can put it in programming mode.

But why go with a cable? Why not put the Buddy Sink board inside the radio itself, with a slot for the USB-C plug? Because a Buddy Sink board is $30, that's why! With a smart Power Delivery cable, I can support a whole collection of 12v QRP radios with the same board setting (12v, 2.5A). With a Y-adapter, I can even supply power to both my KX3 and PX3, though I really wish it had more current. To use a sink in each radio would be a very expensive solution, though it would of course work. It also wouldn't be necessary to leave a way to reprogram the board, since it would only need to supply one range of values, the one necessary to power that radio, and no other. But this is a far more flexible solution, and a far cheaper one!

Now that the smart cable is out of the way, what about the OTHER end?

There are a number of Power Delivery options for power banks and chargers. I bought a 45W GaN (Gallium Nitride) PD wall charger as a backup for my USB-C Chromebook, but found that it also charged PD power banks quite adequately and quickly. Since it is a PD device, it can also provide mains power to the PD smart cable, and is smaller than a deck of cards. The battery banks I purchased are a 10000mAH model and a 26,800mAH model, both by RAVPower. Both will supply around 30W of power, and will power any of my QRP radios at full output, including the KX3 at 10W.

They may not be able to supply as much juice at 12v/2.5A as a dedicated 12v battery, but they also don't weigh nearly as much or take up nearly as much space as a 12v battery. I have a Talentcell 12Ah LiFePO4 battery that weighs about 2 1/2 pounds. The RAVPower 10000mAh PD bank weighs about 6 ounces. The 26,800mAh PD bank weighs about 15 ounces. They also cost much less. The 10Ah model cost about $20, the 26.8Ah, about $50. The 12Ah battery cost around $100, and appears to be no longer available from Talentcell. By my calculations, the 26,800mAh bank should provide around 8,250mAh at 12v, and the 10,000mAh bank, around 3,000mAh.

To give a real-world test to this technology, I charged the 26.8Ah RAVpower pack completely, then connected it via the PD smart cable to my 40m QCX transceiver. I was able to run it, with intermittent transmitting, for 7 hours before I personally got too tired to continue the test. The power bank had only reduced its available power by a single indicator light, roughly 25% of its total. Now, it's certain that if I'd spent that time ragchewing, it would have consumed much more power, as 5w out takes a lot more juice, but I'm not a ragchewer on CW as yet. For casual use, this seems like an adequate power supply for the size and weight. For a device that only provides 8.25Ah at 12v, it seems quite effi-

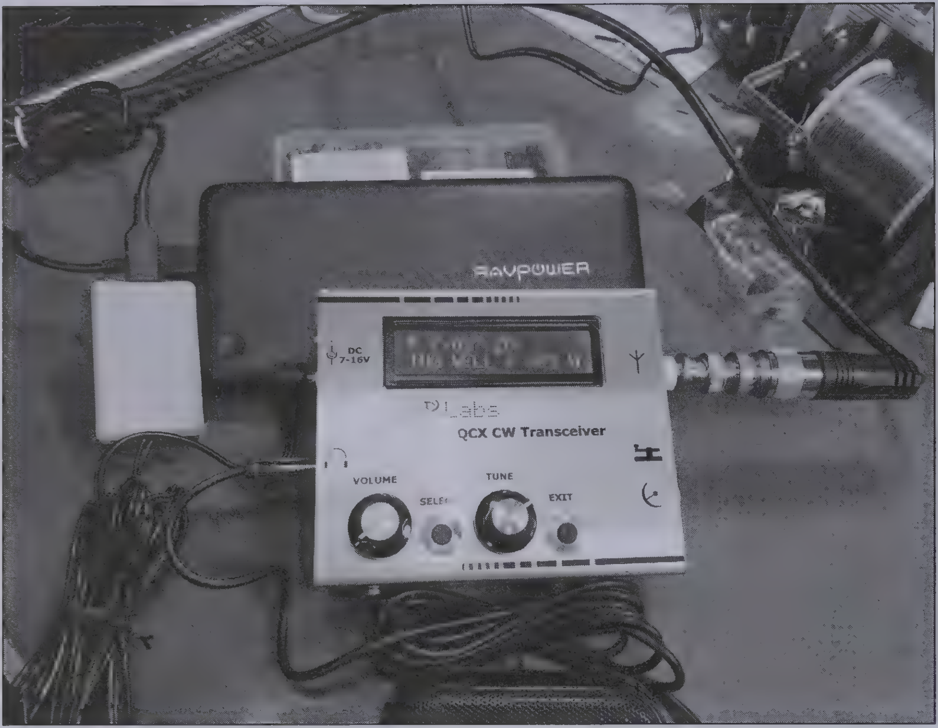


**Photo 4—RAVPower Buddy Sink Cable and QRP-Labs QCX 40m Xcvr- during a 7-hour test.**

cient, powering a 5w transceiver for 7 hours with only a 1/4 reduction in capacity. With greater transmission time, this would certainly be a greater draw on the power bank, but even if it were 1/2 or 3/4 discharged, that's an 8-hour day's worth of continuous operating in a battery bank 1/4 the size of the 12Ah Talentcell I have.

It's also a multi-tasker. It can charge my phone via the USB-A port while operating the QCX. It can charge my USB-C Chromebook. It can charge other USB devices, such as my watch, or the flashlight I wear on a chain around my neck. It can charge my Baofeng BF-T1 Mini 70cm handy-talkie. It can charge my electrolytic water purifier, which equates to 150 liters of purified water. It can run a USB LED lamp, or my TS100 soldering iron. Except for the soldering iron, I'd need an adapter to use the 12v battery on any of those other devices.

I also have more options to charge it back up. I have a solar panel set, also by RAVPower, which can charge either of the PD power banks. I also have two different thermoelectric generators, that provide USB level power from a strong heat source. I can make hot water for drinks or freeze-dried food while charging the power banks. If my car is available, I can recharge the banks from my lighter socket, a source that isn't clean or stable enough to power the radios directly. I can use the GaN charger to recharge the banks, or I can run the radios from that charger with the smart cable while I have access to mains power. It's all very compact and lightweight, making it easier to transport into the field, such as when hiking on a trail or climbing a mountain. (I'm disabled, so my hiking and climbing days are over, but I still go to parks to operate, on picnic tables convenient to nearby parking!) Talentcell put a battery management board inside the case for the large battery, so it can be charged from a charger for a lead-acid battery, but that would still require AC mains power to use!

Power Delivery is still a very new power bank technology, but it appears to be getting more popular. I think it'll be easier in the long run to use such multi-tasking power bank options to run portable ham radio gear than to lug about heavier and less convenient power sources as the technology improves over time. I have a new PD power bank on order, also by RAVPower, a 20,000mAh model with a digital power meter, so I can better gauge how much of the power bank's capacity is being consumed during use.

**Update:**

From some questions I've received since posting this, I have a couple of points to add:

- If your power bank has a low-drain timeout feature (it shuts off if the device you connect doesn't draw enough current), it will NOT turn off if your radio doesn't draw a lot in receive mode. The power bank is not seeing the RADIO'S consumption level, it's seeing the handshake from the sink board, which does not automatically turn off if the draw is "too low".
- There is no oscillator noise from the sink board because it is not boosting 5v from the power bank to 12v. The board is requesting 12v from the power bank, and the power bank is supplying it under the USB-C PD standard. So there's no oscillator boosting the voltage, hence, no noise from the sink board.
- You need to use a USB-C Power Delivery power bank for this. Qualcomm fast-charge is a different standard, and will not work. There will be a "PD" logo on the power bank if it is supported, and should say it is Power Delivery in the documentation. Here is a document explaining the PD standard:

http://www.ti.com/interface/usb/type-c-and-power-delivery/getting-started.html

*—73, Gwen Patton, NG3P*

**Links to Items:**

PD Buddy Sink: https://www.tindie.com/products/clarahobbs/pd-buddy-sink/

ZY12PDN Sink: https://www.amazon.com/gp/product/B07T2858G6

RAVPower 10Ah: https://www.amazon.com/gp/product/B07Y9QYCDC

RAVPower 20Ah: https://www.amazon.com/gp/product/B07TF73QZS

RAVPower 26.8Ah: https://www.amazon.com/gp/product/B01LRQDAEI

Inateck 45W GaN Charger: https://www.amazon.com/gp/product/B0719KV9PH

3d Printed PD Buddy Sink Case: https://www.thingiverse.com/thing:2847318

◆◆

# The Toroid Whisperer

Bill Hulley—K7WXW

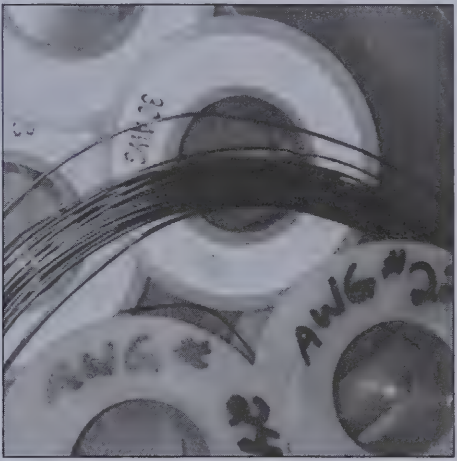
### Learning Patience One Turn at a Time

On the bench in front of of me is a half-empty printed circuit board in a vise, that I am not working on right now, and a just-finished one, which I am. It is supposed to be a QRP antenna tuner, a piece of gear that matches antenna impedance, which can vary, to an unchanging radio impedance. While a careful physical inspection of my work doesn't reveal any misplaced parts, solder bridges or other assembly calamities, the tuner isn't tuning. It is doing nothing other than being about as passive as any grouping of passive components I've ever worked with. Signal in, nothing out.

I have a suspect or two. This kit involves winding and installing toroid inductors, something I've never done before. The instructions are straightforward but the details are daunting: counting turns of wire around a tiny ferrite donut, with taps along the way and making three sets of overlapping windings. I find it easy to miscount turns or put a tap in the wrong place and getting the enamel insulation off the 24 AWG wire so the coil can be soldered into the board at five points is a real challenge.

Unlike most components—capacitors, transistors, switches, lights—that a kit builder buys in ready-to-use form, inductors usually arrive as a ferrite core of some sort and a bundle of wire. The sight strikes fear into the heart of a new builder: winding inductors has such a longstanding reputation for being difficult that there are folks who get paid to make them for hams that don't want to make their own. I am not one of those hams. So far.

Since getting my license, I've built half a dozen small kits like this antenna tuner. When I figured out that I wanted to explore home brewing, it seemed better to start with gear that someone else had already designed and which works if built as instructed. Kits provide a gentle introduction (or in my case re-introduction) to schematic reading, soldering, electronic components identification and all the other things that make up the how of building electronic gear. Kits were a good entry point for me; though I've had to do rework on every project, I've not had an unfixable failure. Yet.



This time, though, I am stumped. After trying and failing way more than once to correctly wind and install the two inductors in this kit, I am starting to think it's time to call a toroid whisperer. I didn't account for left vs right handed winding consistently, so some of the wire ends finished on the wrong side of the coil. I miscounted (twice) the number of turns to a tap. I wound one of them correctly (I think) but didn't get all the enamel insulation off two of the wires, which I figured out after I had soldered three others in place. I am not sure what other variety of mistake is possible but it seems likely I will discover them all before I get this thing to work.

Toroid winding is a lesson in accuracy, patience and letting go. Especially letting go. When I find it hard to admit that I've made a mistake—like I did while winding these inductors—I end up investing a lot of time and energy making less-than-well-thought-out repairs. Let me spare the new toroid winder some pain: trying to fix a badly wound toroid is always a mistake. Even if you manage to move the tap into the right position or whatever—which is hardly ever possible—the end result inevitably has some other kink or nick that will haunt you later in a much harder to find way. The only thing worse than a not-working toroid is one that sorta works. So… Lesson One is admitting when I've bungled something, stepping back from it, and almost always, starting over.

Winding toroids also teaches that accuracy is paired with patience. Twenty-two turns is not twenty-three or twenty-one-and-one-half. Ending up inside the toroid is not the same as outside. When you make an inductor, if you get it wrong, the circuit doesn't work as it should or doesn't work at all. And the only way to get it right is to work slowly, methodically, and patiently. It is difficult to count turns or get wire to lie flat if you are in a rush and easy if you aren't. A well-made toroid inductor is a physical manifestation of accuracy borne of patience: it has the right number of turns going the right distance around the donut with the right spacing. It looks like it was done by somebody who cares about doing things right as surely as one that doesn't says the opposite.

The inductor sitting in front of me, which I have clipped off of the printed circuit board, does not have this look. I can see where I rushed the winding: it isn't evenly spaced and doesn't lay flat against the toroid. Under a magnifier I can also see where I left enamel on two of the leads, which means they weren't making good contact in the circuit and at least two spots where I kinked the wire trying to correct the winding direction.

### So, Back to Work...

After clearing the printed circuit board through holes of the wire bits and solder left when I removed the inductors, I set it aside and start clipping the wire from around the each toroid. I will work on them during tomorrow's bench session, after I read the instructions again, study the drawings and track down a fresh roll of wire. I will set aside an hour for each, rather than fifteen minutes, and check all the connection points with a meter before I solder either of them onto the board. I figured out a way to check the windings for direction and count: make a photo of the finished inductor, print an enlarged copy, and tick off the windings with a pen.

I imagine that this approach will greatly improve the chances of my antenna tuner tuning. Maybe I won't need the whisperer after all.

■■

*We hope the project winds up well, Bill! (pun intended) —QQ staff*

# An Effective Phased Array for 40 Meters

Jim Bailey—AJ8S

aj8s@ysobailey.net

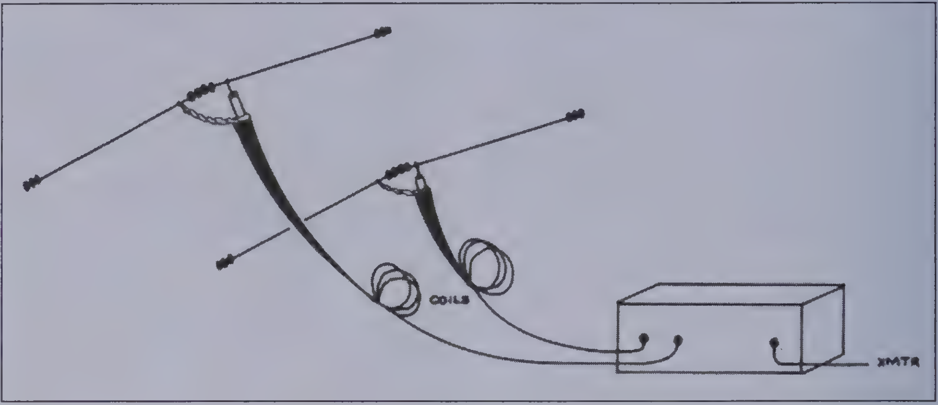


**Figure 1—A 2-element phased array provides transmit gain and valuable receive directivity.**

An aspect of QRP which has always appealed to me is that it is a really good test of how well your antennas work. I started out in QRP with an HW-8 as my only rig and spent several years building wire antennas before even considering QRO. One of those antennas was and still is a 40 meter phased array of inverted vees. What I will describe also works for dipoles, loops, verticals, bazookas, etc. as the elements.

You do get 4 dB of gain with two driven elements (2.5 times the radiated power) but the real advantage is what you can hear. This antenna really shines QRP to QRP. To get high cancellation of unwanted signals and noise you need to precisely adjust the relative phase and magnitude of the currents flowing in the two elements. Coax phasing will do this for one frequency and one path and is hard to adjust. By putting the phasing circuit in a box in your shack you can get near perfect cancellation up and down the band for any direction accept directly off the sides. Of course band conditions will still affect scatter and angle of arrival, but with this antenna you will become acutely aware of these effects.

What about the antenna elements? I have a single rope between two trees about 35 feet apart which runs east and west at about 40 feet above ground. My two inverted vees are supported by this rope at their centers and the ends droop and are tied off where ever it is convenient. The wires run north and south and the two inverted vees are 25 feet apart. Spacing can be from 1/8 to 1/4 of a wave which is from 17 to 35 feet on 40 meters. Closer spacing makes the tuning more critical but will still work.

The coax feed lines should be identical in length and multiples of an electrical half wave. Typical coax has a velocity factor of 66% so this means that at 7.1 MHz the cables would both be 45.7 or 91.5 feet long depending on how far it is to the shack. (A bit longer if you use the 78% $V_f$ foam coax.) Note the two center conductors are on the same side. When erecting the two elements care must be taken to get them tuned to resonance as closely to each other as possible. Ideally they would both have 1:1 SWR at your desired operating frequency. To do this you need to tune each element with the other element removed. This could mean that you allow the wires of the unwanted inverted vee to hang vertically or you could just pull up one element at a time.

The schematic can be divided into four parts: a simple matching section (L1, L2, C1, C2), a series circuit to make the current lead in one element (L3, C3, C5), a second series circuit to make the current lag in the second element (L4, C4), and a DPDT switch (at right) to exchange the two elements so as to reverse the direction of the antenna. Note that the coils are standard B&W stock either 3/4 or 1-1/4 inches in diameter and 10 turns per inch but you could wind your own inductors if you prefer. L1 is tapped with a 6 position switch.

The variable capacitors have the requirement that they not be in contact with chassis ground. I used capacitors made for this but you could also find a way to mount yours with insulators. Note that all three variable capacitors are connected in common so could be mounted to each other and then insulated from the chassis. The exact values of variable capacitance might be what you can find so long as they cover about 200 pF or more.

My phasor is made in an aluminum box with an epoxy glass PC board to support

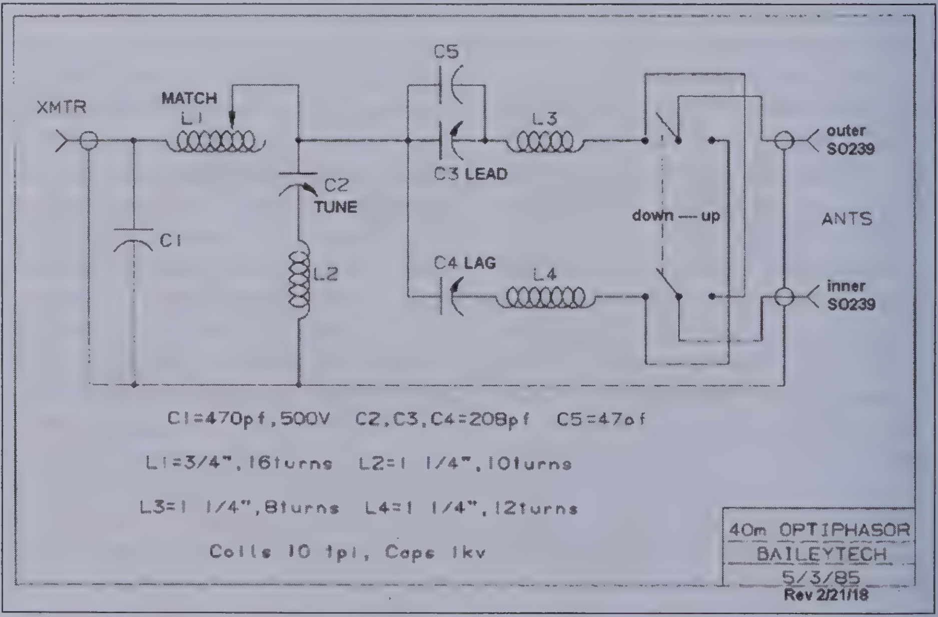


**Figure 2—Schematic diagram of the adjustable phasing box.**

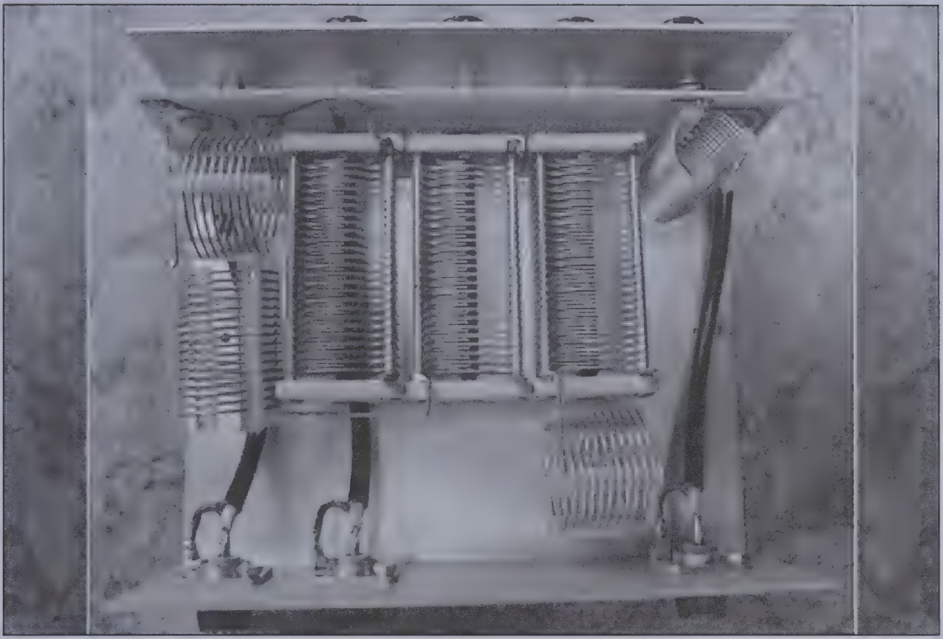


**Figure 3—Inside layout of phasor components.**

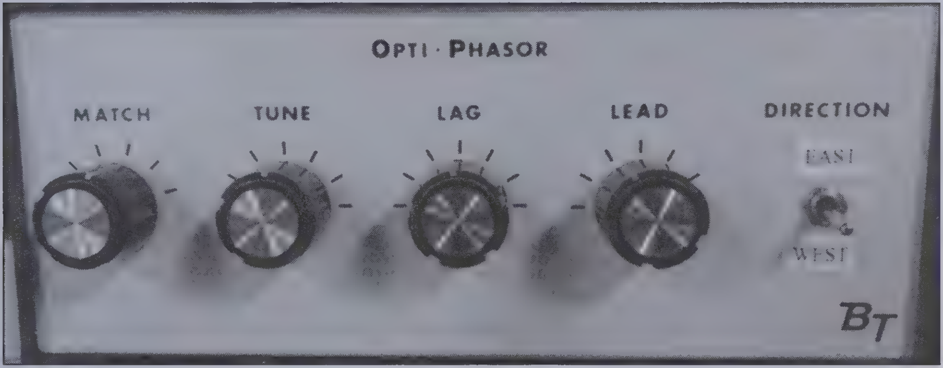


**Figure 4—The phasor's front panel controls.**

the components. Accept for the 3/4 inch diameter matching circuit coil, all the coils are simply supported by their leads. You could just mount everything on a wood if that's your style.

So, how do you operate the phasor? The key is that your receiver is the detector which allows you to adjust the phasing to get a near-perfect cancellation of unwanted signals. Tune in a signal in the opposite direction you want to hear and transmit. Turn off the AGC or turn down the RF gain so you can hear that signal but the receiver AGC is not having an effect. Set the match and tune to mid settings. Then alternately rock the lead and lag knobs so as to minimize the signal by just listening. You may have to flip the switch to get the right direction but you should find a fairly sharp null. The two knobs will interact so be patient and rock them both. Then flip the switch and you should be able to get three S units of reduction for signals which are "off the back."

In the daytime nulls can be very deep depending on where the station is located both in terms of angle of arrival and angle off the center line. At night when the angles of arrival are mostly low you will find the adjustment less critical—you will be able to set the knobs once and mostly leave them alone if you stay in the same portion of the band. And when band conditions are chaotic you may not be able to find a null at all.

Once you have set the phasing to get a good F/B then you can adjust the match and tune knobs to get a low SWR to the transmitter. These settings have no effect on phasing.

I've had a lot of fun with this antenna over the years on 40 meters. I chose that band because a full size 40 meter yagi is well beyond my means but a wire antenna would still fit on my lot and would be easy, inexpensive, and fun. So what about lower bands? I made one for 80 meters but found that the signal arrival angles were typically unstable and all over the place so it was very hard to find a null with the receiver. Of course you could use a field strength meter to get good phasing for one spot on the band and for low angles. 160 meters would be the same. 30 meters would be a good choice but I have never tried it. Maybe you will. I made one using a pair of 20 meter verticals and that worked fine. To make one for other bands you just need to adjust all the circuit values so as to get the same reactances of the inductors and capacitors as this design has on 40 meters. All the capacitances and the inductances go proportionally down as the frequency goes up.

Values for several hams bands are shown in Table 1.

| Band MHz | L1 uH | L2 uH | L3 uH | L4 uH | C1 pf | C2,3,4 pf | C5 pf | Smin ft | Smax ft |
|---|---|---|---|---|---|---|---|---|---|
| 3.75 | 3.55 | 4.77 | 3.49 | 6.08 | 896 | 397 | 90 | 33 | 66 |
| 5.35 | 2.49 | 3.34 | 2.45 | 4.26 | 628 | 278 | 63 | 23 | 46 |
| 7.15 | 1.86 | 2.50 | 1.83 | 3.19 | 470 | 208 | 47 | 17 | 34 |
| 10.12 | 1.31 | 1.77 | 1.29 | 2.25 | 332 | 147 | 33 | 12 | 24 |
| 14.15 | 0.94 | 1.26 | 0.92 | 1.61 | 237 | 105 | 24 | 9 | 17 |
| 18.12 | 0.73 | 0.99 | 0.72 | 1.26 | 185 | 82 | 19 | 7 | 14 |
| 21.2 | 0.63 | 0.84 | 0.62 | 1.08 | 159 | 70 | 16 | 6 | 12 |

**Table 1—Component values for different ham bands.**

# *QRP Classic:* Verticals Without Vertigo

L.B. Cebik—W4RNL (SK)

*From FDIM 1999, and QQ July 1999, October 1999 & January 2000*

*This three-part series on vertical antennas is based on a talk given by L. B. Cebik, W4RNL, at the "Four Days In May" symposium held in conjunction with the 1999 Dayton Hamvention. Shortly after "LB" presented his talk, it was announced that he had been inducted into the QRP Hall of Fame."LB" just passed the 45 year mark on his ham license and was recently inducted into the QRP Hall of Fame. He has taught, lectured, and written on various aspects of radio and electronics, although in recent years he is perhaps best known for his work on antenna modeling, antennas, and antenna tuners. He writes regularly for the* ***QRP Quarterly,*** *maintains an antenna column in the* ***Low Down*** *(Colorado QRP Club newsletter) called "Antennas from the Ground Up," does a monthly antenna modeling column for* ***AntenneX,*** *and has written "An-Ten-Ten-nas" for nearly six years. He has written articles for all of the US Ham Magazines, including QST, QEX, NCJ, CQ, and Communications Quarterly. "LB" has also written a book on antenna modeling, published by Nittany-Scientific. His web site (http://web.utk.edul~cebik/radio.html) recorded its 50,000th visitor in January, 1999, less than a year and a half after the counter was added. Since ham radio does not pay the bills, "LB" fills his spare time as professor of Philosophy at the University of Tennessee, Knoxville.*

*- W1HUE*

## *Part 1: Questions 1 Through 4 Answered*

Horizontal antennas are simple. Verticals, on the other hand, are complex, mysterious beasts around which we have spun horror stories, myths, and gobs of misinformation. We live in terror of the dreaded ground plane, not knowing if we need one or, if we do, what will work and what will not. We fear to load them, for we know not where to place a coil or how to hang a hat.

Verticals look innocent enough. Like a skeleton with one bone, they sit erectly, so prim and properly military in their posture and bearing. But at night, when the wind howls, we have nightmares in which the vertical writhes and bends into pretzel shapes, choking the communications life out of our precious RF.

Books abound on the vertical antenna.[1] However, most appear to be exercises in black magic. Often it seems less that the author has mastered the vertical antenna than that the vertical has mastered the author. Have you ever noticed the reverence with which aficionados of verticals approach their subject? The mystique of verticals is enough to make anyone dizzy.

I wish I were overstating the case, but-alas-I am not. Among all antennas, verticals evoke the largest number of disputes and the most desperate question of all: how do they work?

Quite frankly, I cannot answer that one question-just because it includes everything there is to know about verticals. However, we can explore a number of smaller questions-ten in all-that might give us a hand-hold on vertical antennas. Once we have looked at these ten questions, I hope the myths and misinformation about verticals will dissipate like a rain cloud and let us progress on our own toward filling in the gaps I leave behind. For my goal is to bring verticals down to earth-and at the same time, to bring them up from the murky depths. My aim is to make the vertical antenna as ordinary as the horizontal.

As with any mystery, we clear it up by asking the right questions. The ones I shall pose are not the only ones we might ask-and the approach is not the only one we might take. However, the following questions are good ones and just might lead us to a little more clarity than before.

1. **What makes an antenna a vertical antenna?**
2. **Why do we even bother using verticals?**
3. **Why are verticals so much harder to understand than horizontal antennas?**
4. **Why is "counterpoise" such a dirty word?**
5. **What makes a vertical either a monopole or a dipole?**
6. **What is a ground plane?**
7. **How can we make a short vertical work well?**
8. **How can we make verticals directional?**
9. **How can we make verticals out of wires that are mostly horizontal?**
10. **Just how "good" is a vertical?**

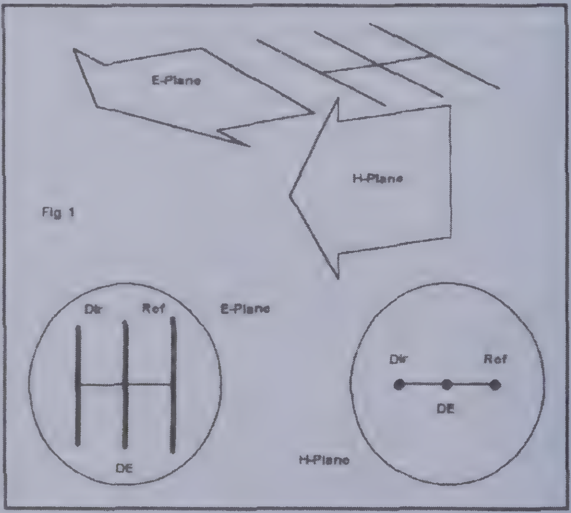
If that is not enough work for one foray into vertical antennas, then I have lost the meaning of the word "work."

### 1. What makes an antenna a vertical antenna?

Antennas are inherently and by themselves neither vertical nor horizontal. The technique of studying a antenna by itself is to place is in free space, with no other object in its field in any direction whatsoever.

Unless an antenna is a dot or a sphere, the antenna will have identifiable planes of radiation. The traditional names for these planes are the E-plane (associated with the antenna's electrical field) and the H-plane (associated with the antenna's magnetic field). Consider **Fig. 1** at the top of the next page. For the Yagi antenna-a very planar antenna-the E-plane is in line with the elements. The H-plane is at right angles to the elements. The fields can use arrowheads to indicate direction a. because the antenna is very directional and b. because the elements define a major plane.

Except for element and object coupling, the magnetic field is far less important to antenna performance at a distance than the electrical field.



Although we shall return to the magnetic antenna field or H-plane before we are done, let's focus on the E-plane or the electrical field of the antenna. This is the field primarily responsible for long distance communications (although one field could not exist without the presence of the other at the antenna).

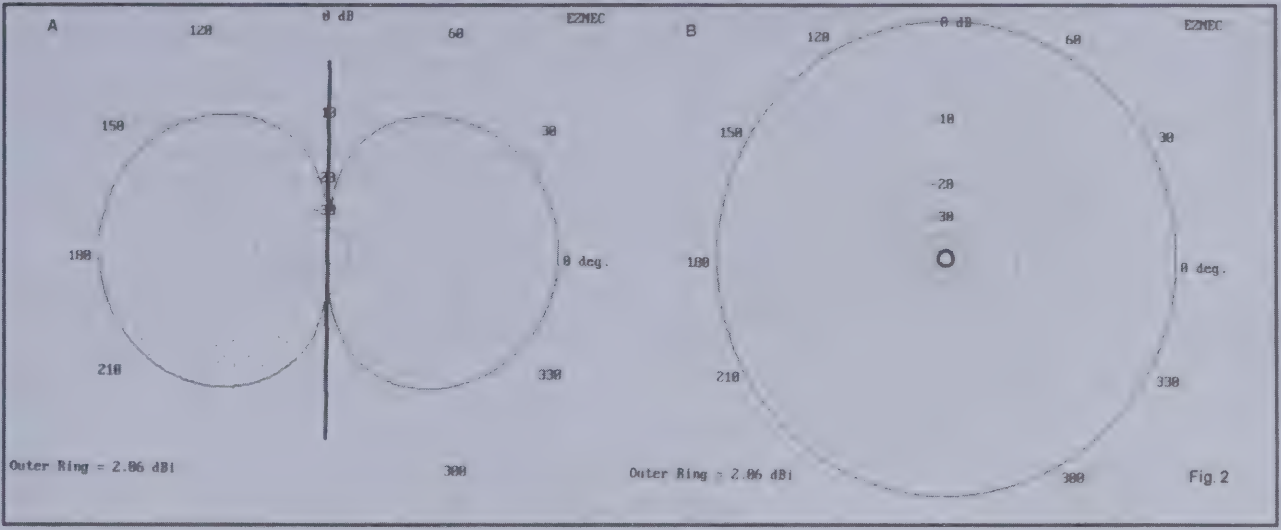


Fig. 2

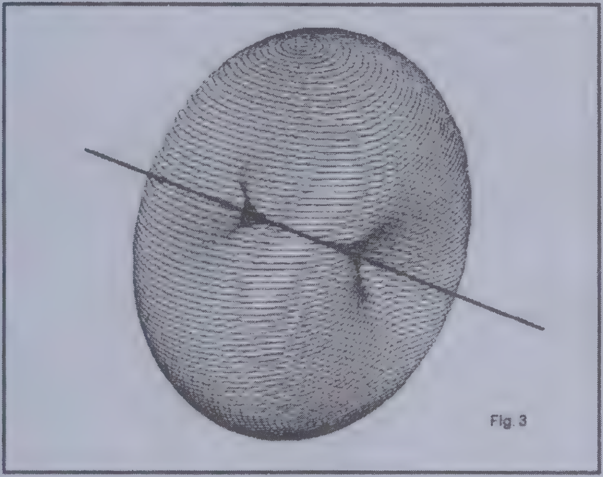


Fig. 3

A simple antenna, like a dipole, has many possible E-planes. In **Fig. 2** below, the left figure shows the shape of any one of them, since it cuts a cross section in a plane with the element. The right figure looks at the element from the end and sees an indefinitely large number of cross-sections or E-plane figures we might make-all just alike. So if we tilt the left figure progressively upward, it will turn into the right figure-and vice versa.

To see the transition, look at **Fig. 3**, a 3-D representation of the same patterns. The antenna is exaggerated immensely to shows its orientation relative to the field pattern. However, these fields are represented at arbitrarily huge distances from the antenna, so that if I drew the antenna to scale, it would be invisibly small.

The familiar donut shape pattern can only materialize in free space. If we place any objects of significant size anywhere in the field, some radiation will reflect from them or refract around them, distorting the pattern and at least taking a bite from the donut. With all antennas we use-except in outer space, perhaps-we live with reflections and refractions and distorted patterns. In fact, we have learned to make use of the distortions to make our antennas to a better job of placing radiation fields where we need them.

Until further notice, we shall concern ourselves only with the E-plane fields of antennas. If we think E-plane only, then we can understand why we call antennas vertically and horizontally polarized-or vertical and horizontal for short. All we have to do is to bring them down to earth, as we do in **Fig. 4.** Now we have a reference plane, namely the surface of the earth, against which to compare the E-plane fields of an antenna. If those fields are parallel to the earth's surface, the antenna is horizontally polarized. If the fields are at right angles to the earth's plane, then they are vertically polarized.

The scheme is so simple that you would think that no one could confuse it. However, antennas themselves give us good reason to get confused sometimes. In the real world, hardly any antennas are purely vertical or purely horizontal. Instead, even antennas that we think of a purely one or the other have some remnant (E-plane) radiation of the opposite polarity. **Fig. 5** provides a couple of samples.

The top antenna is a horizontal dipole. As purely horizontal as we like to think of the dipole, it retains a tiny vertically polarized component, mostly caused by ground reflections which interact with the element. The amount is insignificant in terms of having any affect on the overall antenna pattern. The horizontally polarized field is not distinguishable from the total antenna field.

The bottom antenna happens to be a half-square, which has a larger horizontally polarized radiation component to go with the predominantly vertically polarized radiation. The remnant does have a small but determinant affect on the overall antenna pattern, as evidenced by the slight smudge in the larger pattern outline: the total field and the vertically polarized field are not absolutely coincident.

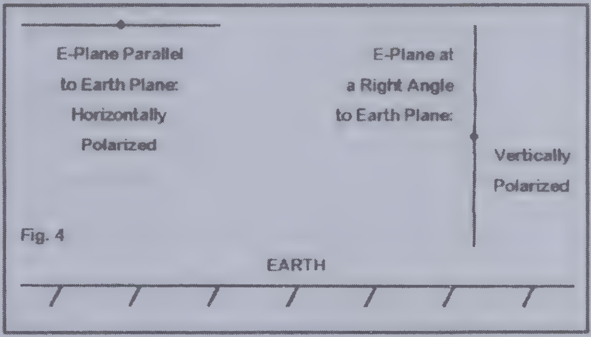


Fig. 4

So when we call an antenna a vertical, what are we saying? We are simply noting that the dominant orientation of the electrical fields from the antenna are at right angles to the earth's surface. Nothing more, nothing less.

**2. Why do we even bother using verticals?**

There is a myth that says, inherently, verticals are inferior to horizontals. Consequently, they are always the last option, perhaps when you are faced with using a vertical or not using any antenna at all. Although there is a way in which we can give this claim some truth, in fact it is not event a half truth-more like about an 8th truth at best.

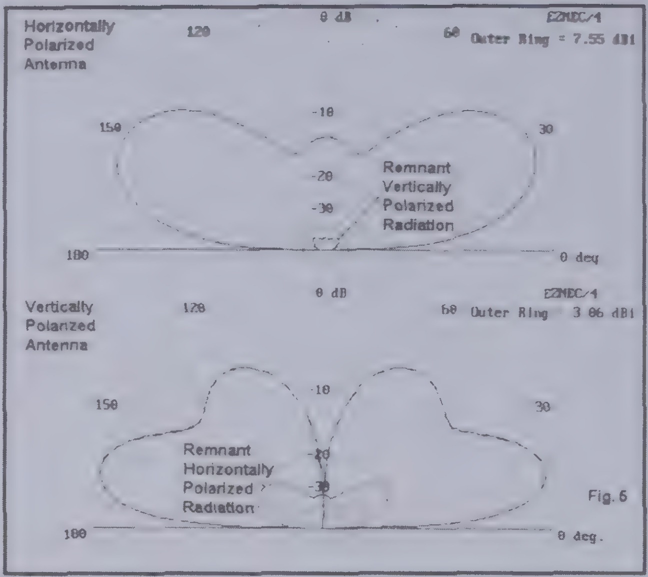


Fig. 6

Verticals have their best use when we define some total communications picture. Then their use makes eminent sense. So let's construct some communications scenarios.

1. From lower HF down through VLF, the surface wave component of an antenna's radiation is important. From lower HF on up, the surface wave is too weak and dissipates too soon for more than community communications. In the AM broadcast band, a surface wave can cover a radius of 50 miles with modest power (relative to broadcast powers). At VLF, with enough power, a surface wave will go around the world.

Surface waves are most efficient when vertically polarized. Hence, AM broadcast antennas are vertical to enhance their surface wave propagation.

2. Mobile antennas from HF through UHF are vertical for two major reasons. First, moving objects, like cars and boats, do not have much surface area to support horizontal antennas. (The 6- and 2-meter halos are exceptions.) Second, vertical antennas tend to be omni directional. For local communications, where a vehicle may undergo many changes of orientation, the vertical means a more even signal strength relative to the other terminal of the path. In most cases of local communications, we are using ground wave, but not the surface wave subdivision. Instead, we are using point-to-point communications.

The other terminal within this local communications ring employs an antenna which offers the highest promise of maximum signal strength. In point-to-point communications, signal polarity is largely sustained along the path. Some polarity skewing occurs because of signal refraction from objects, but not in the main. Hence, to avoid the signal path loss occasioned by cross polarization-which can run from 3 to 20 dB, depending on circumstances-the other terminal uses a vertical antenna as well.

3. Skywave propagation results in polarization skewing, thus voiding in large (but not total) measure the polarization differences between vertical and horizontal antennas. However, some operations dictate that they be able to receive from and transmit to all directions equally well and simultaneously. Since vertical antennas (but not necessarily vertical arrays) are omnidirectional, they are often the only antennas suited to the communications need.

4. In the war between vertical and horizontal antennas, most horizontally polarized antennas do not have an elevation angle of maximum radiation that is low enough to match long distance propagation angles until those antennas are at least 1/2( up-or higher. Above that height, going horizontal is seldom a bad choice, but below that height, long-distance communications may suffer with a horizontally polarized antenna. Vertically polarized antennas at or near ground level (as well as those mounted some distance above the ground) inherently have low elevation angles of maximum radiation.

Every installation has its own special concerns that determine the maximum height (and horizontal spread) for antennas. Since 1/2( at 40 meters is about 70 ft and 135 ft at 80 meters and 275 ft at 160 meters, achievement of significant radiation at low elevation angles is often impossible for feasible horizontal antennas. Hence, the vertical antenna becomes the antenna of choice.

5. Some installations lack the horizontal space needed to a horizontally polarized antenna. In such cases, a vertical antenna with compact horizontal dimensions may be the only feasible antenna.

This last case may be the only one in which one should think that they are using second best. However, it is likely much more productive to devote one's thinking to improving the vertical installation to make it the most effective possible. The items in our list are all very good reasons for using verticals. Although the list is not complete, you can fill in the rest of the possible entries yourself.

### 3. Why are verticals so much harder to understand than horizontal antennas?

Unless a vertical antenna is very high above the ground-perhaps a wavelength between the earth and the antenna bottom-the antenna will interact with the earth in ways more complex than the simple interactions involved with horizontal antennas. Hence, there is a larger set of terms we have to master in order to fully appreciate what is going on with a vertical.

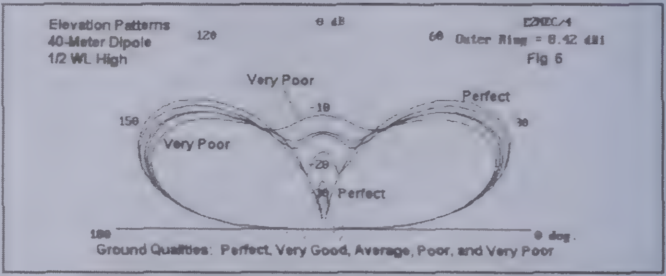


Fig 6

We can illustrate the complexity by a simple demonstration. Fig. 6 shows a series of elevation patterns along the main axis of radiation from a horizontal dipole placed 1/2( above ground. The horizontal antenna is concerned with ground quality mostly at a distance from the antenna-the region sometimes called the Fresnel region at several wavelengths distance from the antenna. Here, the ground quality has an affect on the reflection of radiation to combine with the direct radiation to form the main elevated beam. Note that from perfect to very poor ground, the increments of signal strength change are quite small and very regular. They progress downward from perfect to very poor in neat steps.

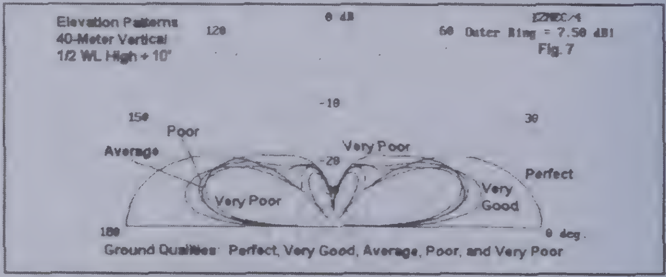


Fig. 7

**Fig. 7** shows a vertical dipole that begins 10 ft off the ground and is 1/2( long. If we could have perfect ground, the antenna would provide very significant gain. Salt water (not illustrated here because it would bring tears to the eyes of most land-locked vertical users) approximates the perfect pattern quite closely. However, over typical soils, the skywave signal strength is reduced considerably from its ideal. Notice also that the changes are not as regular as with the horizontal antenna. Poor soil produces a slightly stronger skywave signal than does the supposedly better average soil.2 This phenomenon does not occur at every height at which we might mount the vertical.

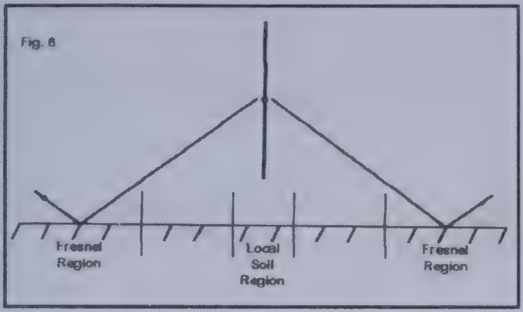


Fig. 8

Because verticals-whether or not they are self-contained or use ground planes-are so interactive with soils, we must acquaint ourselves with soil behavior and peculiarities. For example, at lower HF, RF penetrates the soil much deeper than at upper HF. Since soils are very often layered, with each layer having difference conductivity properties, we may not be able to predict or to model with precision the performance of a vertical antenna at 80 meters, although the same antenna at 20 meters might be very predictable. Likewise, some soils-such as those in desert areas with sandy salts-may change with the weather-becoming more conductive for a while after a ran storm-the performance of a vertical may change from day to day.3

Even though some vertical designs-those we shall eventually classify as self-contained-are dependent for the most part only on soils in the Fresnel region, vertical monopoles that use ground planes are also dependent upon soils immediately beneath the antenna.4 Hence, we must not only concern ourselves with general soil properties, but as well, we must be able to distinguish between local and distant soils, as sketch roughly in **Fig. 8.**

As complex a subject as soil is when juxtaposed with antennas, the major hindrance to the understanding of vertical antenna behavior are the partial truths that parade as universal generalizations. Here are a few, given without much comment:

1. Verticals always need a ground plane. Wrong.
2. Verticals are omnidirectional. Not all are.
3. Verticals are always weaker than horizontals. Not always, and it depends at which elevation angles you look. Besides, the stronger reception might be mostly noise.
4. A short vertical is next to useless. Very wrong.
5. If you cannot put down a large ground plane, you had better add lots of copper sulfate to your yard soil. Only if you are seeking to kill the grass.
6. Verticals are dangerous to other people in the area. Actually, this can be true, if one installs the antenna carelessly, without due attention to safety. We could spend an entire hour on the subject of differentiating RF exposure (usually not a problem, especially at QRP levels) from RF contact (and the inevitable RF burn). It is the latter that forms the chief danger to folks in the area, but preventing contact is a simple matter to fix by any of a dozen different techniques, ranging from fencing beyond touching range to elevating the antenna out of reach.
7. Every vertical needs a counterpoise. A what?? Let's spend a few moments on this term.

### 4. Why is "counterpoise" such a dirty word?

The term "counterpoise" comes from mechanical systems contexts. It means a counter-balancing force, ordinarily a weight on the other side of a fulcrum. It wormed its way into antenna work as a term that covered up ignorance under impressive sounds. If some hank of wire seemed necessary to make an antenna work, but it had no name officially condoned as the name of an antenna part, it was dubbed a counterpoise. This name was reserved mostly, but not always, for antenna parts that did not seem to contribute to radiation.

There is nothing in the world of antennas that corresponds to the dead weight facet of the concept of a counterpoise. Every part of an antenna contributes to the antenna far field pattern (except those parts that we specifically design to have self-canceling radiation). Hence, there is no such thing as a mere counterpoise. We should do our best to expunge the term from the language of antennas.

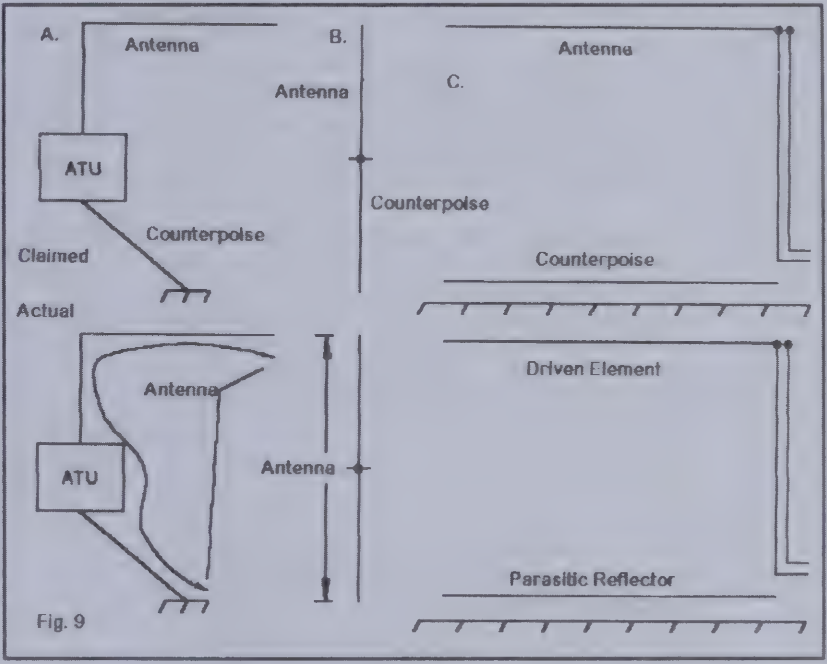


Fig. 9

illustrates three recent applications of the term in ham literature. Case A involves a wire running for some specified number of feet from the ground terminal of an antenna tuner to ground. However, The entire length of wire from ground to the far elevated end is the antenna, with the feedpoint at the ATU simply off center.

Case B. treats the lower wire from a 1/4( vertical as a counterpoise, even though-in its vertical position-it constitutes the other half of a common vertical dipole.

The third case (C) is a modern adaptation of a very old scheme of running a second wire at or near the ground under a horizontal wire, ostensibly to improve some mysterious relationship between the upper wire and the earth. Actually, the horizontal antenna performance remains unchanged, and the wire becomes a trip for anyone careless enough to walk through it. At best, it serves as a parasitic reflector, possibly converting a general-purpose antenna into an NVIS (Near Vertical Incidence Skywave) special.

In every case, the so-called counterpoise can be analyzed (and modeled) as a part of the antenna. Hence, let us simply set the term aside as one we no longer need and replace it with specific terms that correctly identify the parts of antennas.

Stay tuned for more...

## 5. What makes a vertical either a monopole or a dipole?

Having spent a good bit of time clearing away problematic ideas that get in the way of understanding verticals, let's make some positive progress. One of the most confusing questions we can get our hands on is when a vertical is a monopole and when it is a dipole.

The question is not difficult if the antenna wire is 1/4λ long or shorter. A quarter wavelength wire fed at its end in free space presents an impossible situation that has no resemblance to a real antenna, like one we might stick in the ground. It always wants some form of completion, whether as a real or a simulated ground plane, so that we can feed it at or near a current maximum.

The problem that boggles our minds is when the vertical antenna element is longer than 1/4λ. We can in fact have vertical monopoles that are anywhere from 1/4λ to at least 5/8λ long. We can also have vertical dipoles that range from short (1/3λ to 3/8λ long) to well over the standard 1/2λ length.

The way to figure out which is which lies in the feedpoint and system: where are you feeding the antenna and how. As to positions, we have roughly two choices. We can feed the antenna at the lower end or we can feed it in the middle. (The upper end is theoretically available as a feedpoint, but somewhat inconvenient except in some nearly vertical sloper designs.)

Our choices as to the method of feed are also a pair. We can feed the antenna at a point at or near a current maximum. We may also feed the antenna at a voltage maximum. We are accustomed to matching a high-current, low voltage, low impedance source to a low impedance antenna feedpoint. We think of such points as the base of a vertical monopole or the center or near center of a dipole. Voltage feeding involves the use of high-Q tank circuits with the power coupled in and the antenna attached at or near the "hot" end of the tank.

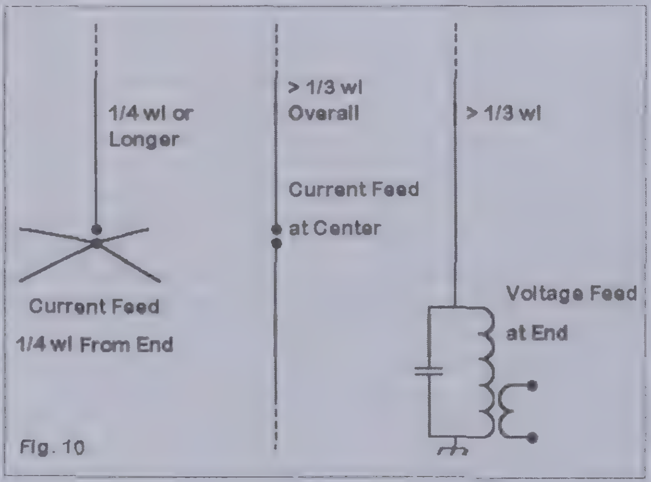


Fig. 10

The sketch in **Fig. 11**, shows the current magnitude along both the vertical and each of the (4) radials for a sample 1/4λ monopole with ground plane. The current in the radials at the junction is 0.25 of the source value of 1.0. Note the current peaks in the radials near the junction of elements.

The middle case of **Fig. 10** is clear enough on its own. The antenna is current fed for lengths between 1/3λ and nearly 3/4λ. Because the antenna is balanced about a current maximum at its center, it requires no ground radials to establish that balance.

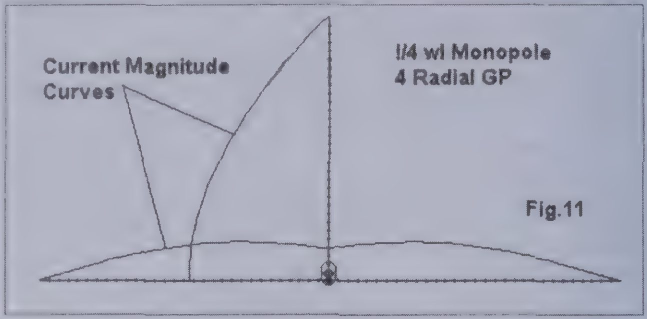


Fig.11

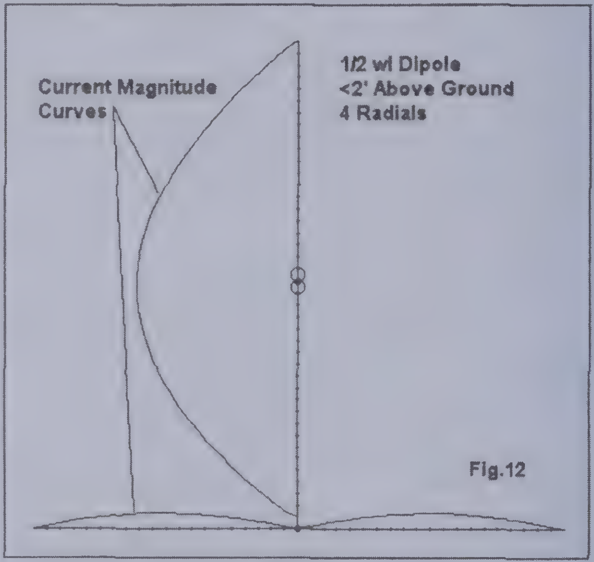


Fig.12

In the model sketched in **Fig. 12**, the 1/2λ antenna has been placed over a system of 4 radials, each 1/4λ long. The current magnitude curves reveal that the current in each radial never rises above 0.1 of the current at the antenna source (1.0), and the current peaks about mid-way down each radial. The gain difference between this little model, with the antenna about 2' above the radial system, is less than 0.25 dB relative to the same antenna in the same position, but with no radial system.

The last case in **Fig. 10** strikes many as similar to the first, since the feedpoint is at the base. However, the tank circuit makes this a voltage-fed antenna, and the current maximum is at roughly the center of the antenna. For proper operation, the antenna requires no radials, but does demand a good RF ground return to the source. If we do lay down a radial system, it is not for propagation, but for the enhancement of the RF ground of the tank circuit. Of course, the link for the low-impedance feeder system could be replaced by a tap on the main coil.

With the end of a 1/2λ antenna at the same position above ground as the model used in **Fig. 12**, the antenna shows the same gain, within about 0.1 dB, as the center fed version. **Fig. 13** shows the current magnitude distribution along the element, with its peak at the center of the antenna, almost identically to the magnitude pattern of the center-fed version. As an end fed antenna, the feedpoint impedance is high: about 1400Ω resistance and 4000Ω reactance. However, before we leave our 1/2λ vertical, let's perform one more experiment.

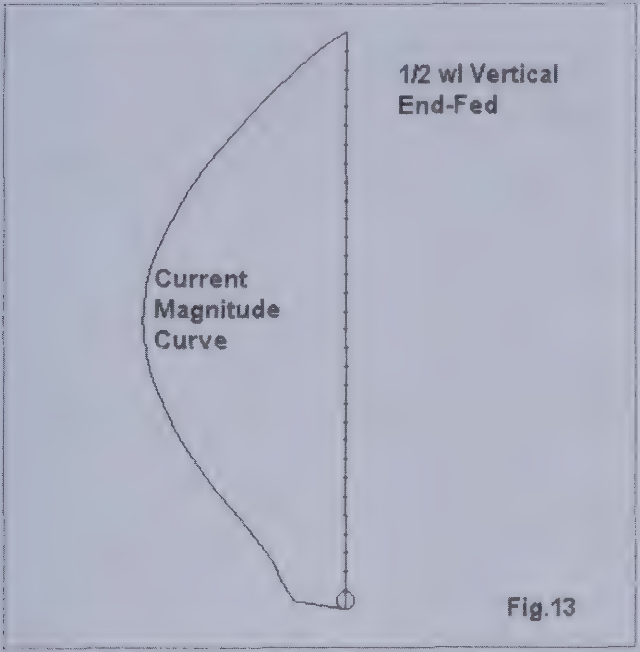


Fig.13

Compare the current magnitude curves of **Fig. 13** and **Fig. 14** below. Shape is more important than absolute value of the maximum shown.

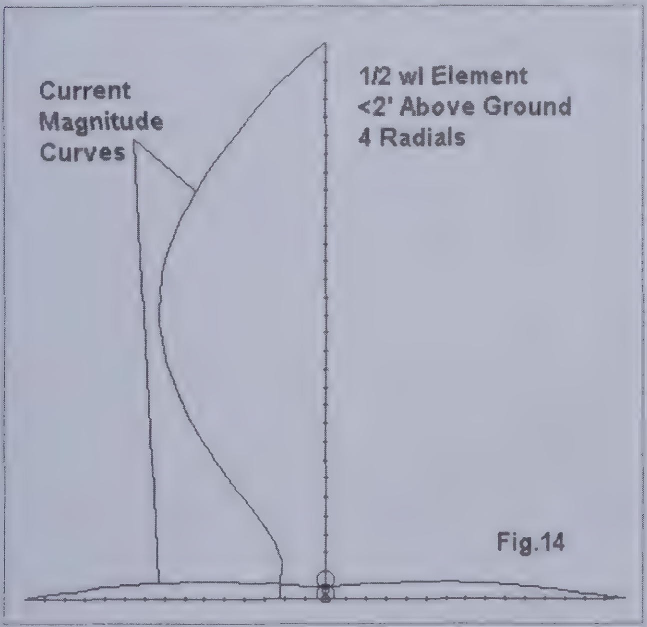


Fig.14

In **Fig. 14**, the 1/2λ element was placed above 4 radials and fed against them. The result was similar to that of the 1/2λ center-fed element placed above the same radial set. Gain differences are less than 0.1 dB, and the maximum current region remains at the element center. The source impedance is high, and the current in the radials reaches about 0.1 of the value at the vertical element center.

This exercise is not designed to show that radials do not help, since we used only four. However, it does demonstrate that the end-fed 1/2λ element remains exactly what it is whether or not placed above and fed against radials.

## 6. What is a ground plane?

One of the enduring misnomers of all antenna work is the phrase "ground plane." We cannot get rid of it (in the way that we can simply stop using the term "counterpoise"). However, we can do as much as possible to eliminate drawing some of the wrong conclusions that abound.

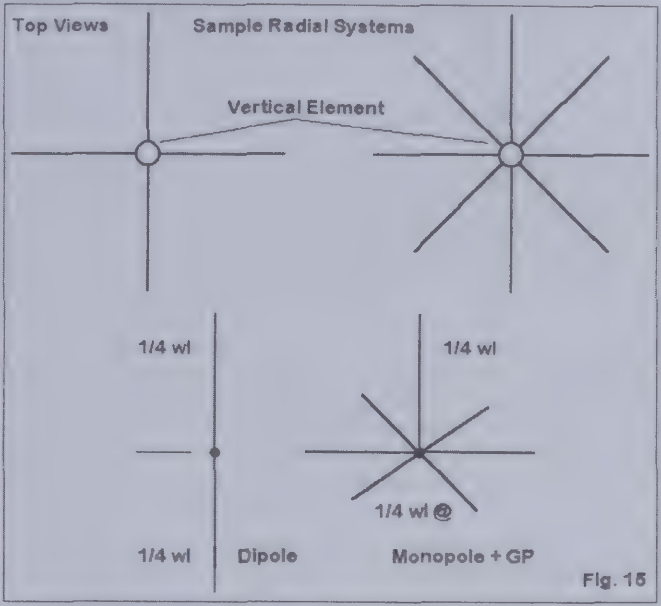


Fig. 15

Let's first treat the "plane" part of the phrase. As revealed in **Fig. 15**, the typical plane consists of a symmetrical arrangement of spokes extending from one side of the feedpoint, where the other side is essentially a vertical element. For the common 1/4λ vertical antenna, the plane spokes are also approximately 1/4λ long. Almost any number of spokes may be used so long as we arrange them symmetrically.

The lower half of **Fig. 15** shows the function of the plane: to replace the radiating lower half of a vertical dipole with a structure that 1) lets the assembly be resonant on some desired frequency, 2) permits the feedpoint at the element-plane junction to be a current-feed point, and 3) eliminates radiation from the plane by cancellation. That is, radiation from one plane spoke is cancelled by radiation from one or more spokes in the assembly. Hence, we may in fact use an odd number of radial spokes to make up the plane, and as few as three will preserve the circular vertical pattern that we prize.

*a. How many radials do I need to achieve maximum performance from my vertical + plane?* The answer to that question depends on the proximity of the antenna to the earth. The closer to the earth – including being in the earth – the more radials are needed.

However, it is not very far above the earth that the use of many radials instead of a few fails to help the antenna. As shown in **Fig. 16**, at a height of 10' (about 0.07λ at 7 MHz) for the base of a vertical + radial plane, performance is not enhanced by doubling the number of radials up to 32 from an initial set of 4. When those radials lay on the earth, as in the lower curve, performance increases continuously with each doubly of the number of radials. And it would continue to improve up to at least 120 radials. (Because there is some question about the accuracy of absolute value values yielded by NEC models for planes near the ground, but not about the accuracy of performance trends, the graph uses the gain with 32 radials as a reference in both cases, showing the lesser gain with fewer radials. 0 dB is an arbitrary reference point.)[6]

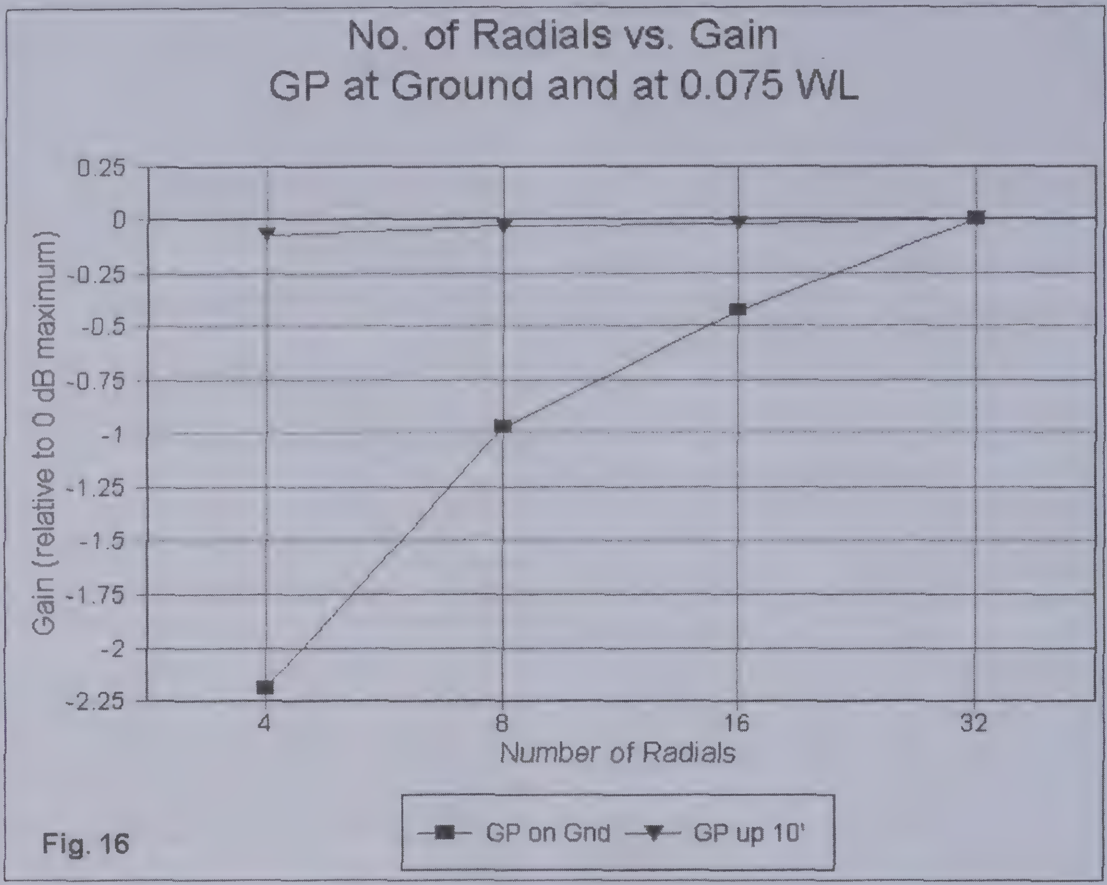

No. of Radials vs. Gain
GP at Ground and at 0.075 WL
Gain (relative to 0 dB maximum)
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
-1.5
-1.75
-2
-2.25
4
8
16
32
Number of Radials
GP on Gnd
GP up 10'

**Fig. 16**

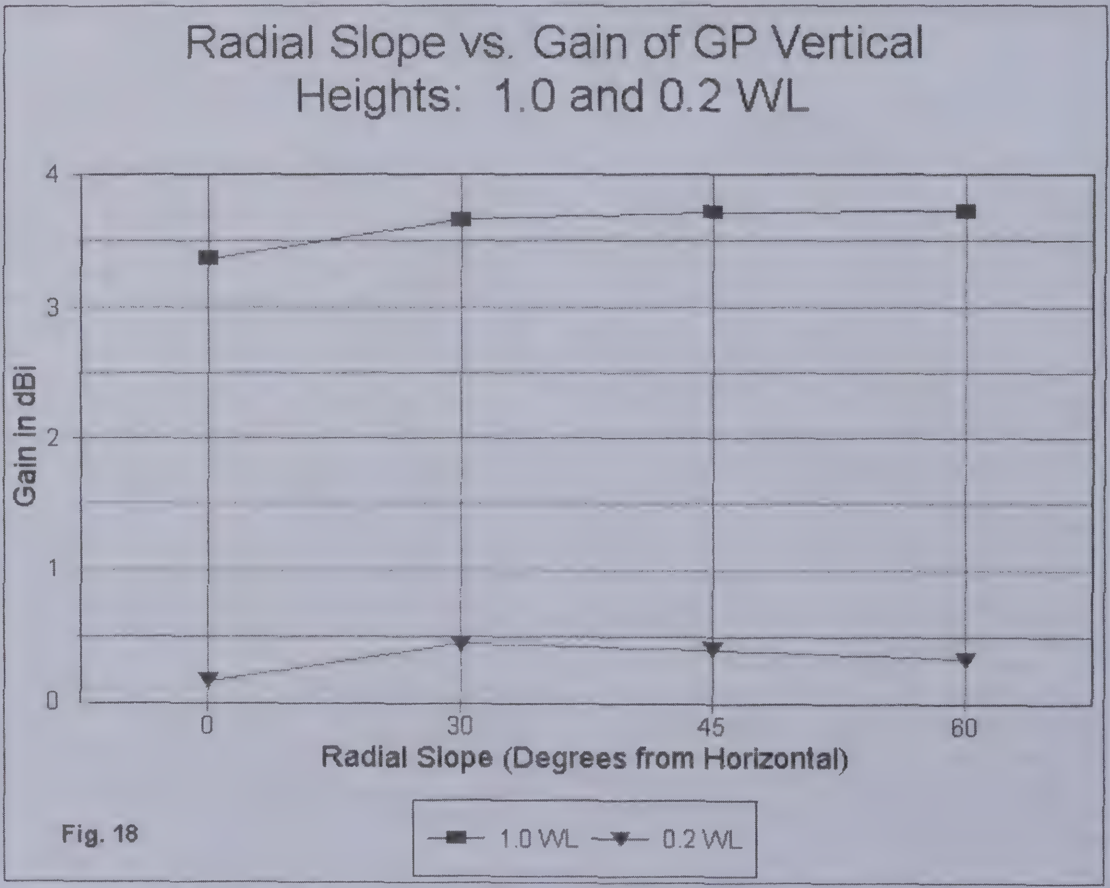
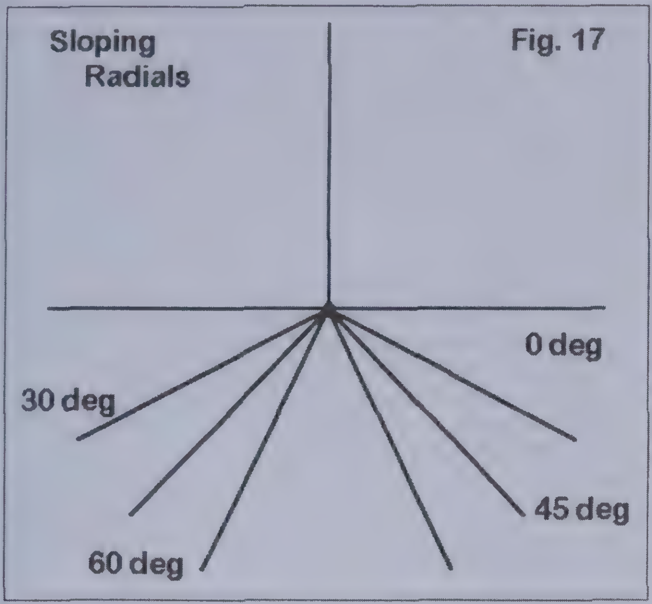

Radial Slope vs. Gain of GP Vertical
Heights: 1.0 and 0.2 WL
Gain in dBi
4
3
2
1
0
0
30
45
60
Radial Slope (Degrees from Horizontal)
1.0 WL
0.2 WL

**Fig. 18**



There are actually a large number of subquestions concerning the radial plane of a vertical monopole. Let's look at them, one at a time.

Notice that this description of the plane makes no reference to ground. In fact, one can model the antenna just described in free space with no theoretical problems rearing their troublesome heads. A ground-plane vertical requires no ground to operate perfectly well.[5]

To the graphed gain, we can also add data concerning the feedpoint impedance as we change the number of radials. For the elevated antenna, source impedance changes by less than 1Ω across the range of radials. With surface radials, the impedance changes considerable, with a resistive component variation of 24Ω and a reactance variation of 65Ω. Hence, the received wisdom for earthed radials holds good: the more radials, the better up to about 120, with about 30 being the minimum number for a long-term, serious installation. For an elevated system, whether on a pole, tower, or roof, 4 to 8 is enough.

*b. What difference, if any, does sloping the radials make to the installation?* **Fig 17** shows several degrees of sloping we might use.

The sloping-radial question implies an elevated vertical because it is difficult to slope 160-meter radials at a 45-degree angle into most kinds of ground. The answer involves two aspects of antenna performance: the gain and the feedpoint impedance. Each answer is partially dependent on the height of the antenna assembly

**Fig. 18** gives part of the answer in terms of the gain of a 4-radial vertical at two very different heights: 1.0λ and 0.2λ. The higher antenna shows a continuous progression of gain increase (although just barely) as the radial angle relative to a flat plane parallel to the earth continues to increase. When sloped, the plane is no longer a purely non-radiating symmetrical system. The horizontally polarized radiation is balanced and self-canceling. However, the vertically polarized radiation – which grows significantly the greater the slope to the radials – simply adds to the radiation from the upper vertical section. In short, a rooftop vertical with sloping radials is actually a form of vertical dipole.

0.2λ for the vertical feedpoint is about the lowest height for this modeling test, because at lower heights, the radials drag the ground. However, the approach of the radial ends toward the ground with steeper slopes actually produces less gain than the max gain angle of 30 degrees.

Not only does the gain change with the degree of radial slope, but so too do the elevation angles of maximum radiation (TO or take-off angles) and, of course, the source or feedpoint impedance. The following small table makes the changes clear.

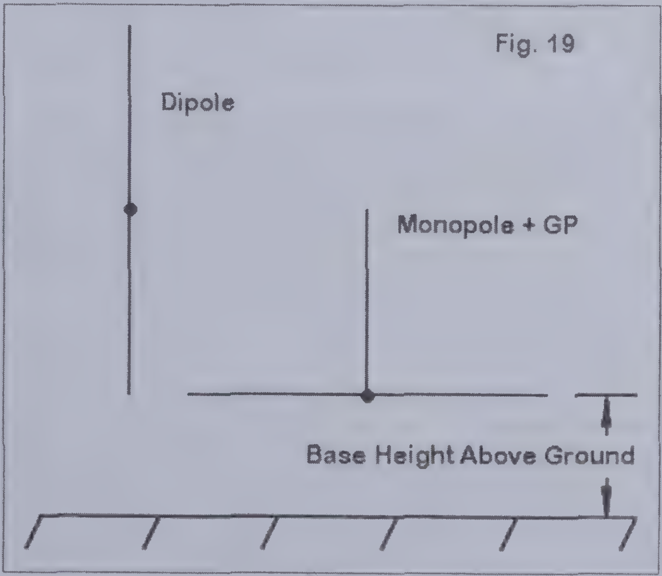
| Radial Slope degrees | TO angle degrees | Feedpoint Z (Resistance) Ohms |
|---|---|---|
| Height: 1λ | | |
| 0 | 26 | 21.3 |
| 30 | 27 | 41.3 |
| 45 | 28 | 49.7 |
| 60 | 28 | 55.9 |
| Height: 0.2λ | | |
| 0 | 15 | 19.4 |
| 30 | 17 | 43.1 |
| 45 | 18 | 56.3 |
| 60 | 18 | 68.6 |

Evident is the more rapid rise in the source resistance as the radial slope angle increases for the antenna whose radials more closely approach the earth. At a slope of 60 degrees, the 0.2λ base height of a 40-meter version of this antenna places the radial tips within 2' of the ground with significant vertically polarized radiation from the lower portion of the antenna.

Equally evident is the small but definite increase in take-off angle as the radials approach the position where the antenna would become a vertical dipole. This latter phenomenon occurs because the growing vertically polarized radiation from the bottom wires comes from a position that is lower than the upper wire, and this portion of the radiation has a higher take-off angle. The overall elevation angle of maximum radiation is a composite of the two angles.

*c. What differences, if any, does absolute height of the antenna base make to performance?* We can only provide a sample modeling test for this question, so the answer will only be partial. However, the results reveal an interesting facet of vertical antenna operation. I placed 40-meter vertical antennas at base heights of 10, 20, and 30 feet. (Base height refers to the lowest extent of the antenna wire or wires.) I used both a vertical monopole with an 8-wire radial system and a full-size vertical dipole. Of course, the top of the dipole was much high (1/4λ higher, to be more precise). The models for the vertical + radial plane used a plane with no slope, that is, with the radials at right angles to the vertical element.

**Fig. 19** shows the basic test configuration, with the results in several performance categories tabulated below the figure



| Base Height feet | Gain dBi | T-O Angle degrees | Feedpoint Resistance Ohms |
|---|---|---|---|
| A. Vertical Dipole | | | |
| 10 | 0.22 | 16 | 79.5 |
| 20 | 0.34 | 15 | 70.8 |
| 30 | 0.28 | 14 | 68.5 |
| B. Vertical Monopole with Radial Plane | | | |
| 10 | 0.20 | 22 | 26.0 |
| 20 | 0.27 | 18 | 21.8 |
| 30 | 0.18 | 16 | 19.8 |

There is little to choose between any of the antennas or configurations with respect to gain. The maximum gain differential is 0.16 dB. The vertical dipoles exhibit a lower elevation angle of maximum radiation for each height because their feedpoints are always $1/4\lambda$ higher than those of the monopoles in this test. As with all of our test models, the higher the vertical antenna base from the ground, the lower the feedpoint resistance. The low value of the feedpoint resistance may surprise some folks, since we are often told that the inherent resonant resistance at the feedpoint of a vertical monopole is 36Ω. It is not. Above about 20' in height, the feedpoint resistance will fluctuate periodically for this antenna between 20 and 22 Ω. The antenna is modeled with a 2" diameter aluminum tube and 0.25" aluminum radials.[7]

More significant is the peak gain within each antenna type at the 20' base height. In fact, the peak for the monopole occurs at a slight higher height than 20' and drops more rapidly when the antenna is placed 10' higher. Why the gain exhibits this behavior becomes clear from **Fig. 20**.

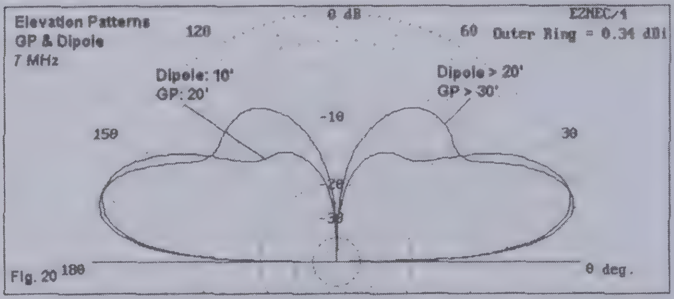


Fig. 20

The pattern of a vertical antenna at a low height shows a single lobe when viewed with respect to the field elevation. Notice that the antenna is relatively insensitive to radiation coming from higher elevation angles. As we increase the height of the vertical, a second lobe emerges at a higher elevation angle. This lobe peaks in the vicinity of a 60-degree elevation angle – too high for the reception of almost anything except atmospheric noise.

Those who use vertical antennas by choice rather than the necessities of a particular antenna site often select them knowing that the gain will not compete with a horizontally polarized antenna they might use instead. However, the signal-to-noise ratio is often improved because atmospherics received from high elevation angles are reduced. Some of that reception advantage disappears if we place the antenna too high, and the second lobe of the elevation pattern achieves full development.

There is a counterweight to this facet of vertical antenna behavior that is especially apt to urban, suburban, and wooded locations. I cannot demonstrate it with a model, but only from the collective experience of many vertical users, including myself. The phenomenon is the dreaded "RF-eating shrubbery." In the open fields of America's great farming states, a ground-mounted vertical has its best home, with nothing but open fields for many wavelengths in any direction. In crowded locations, the presence of significant structures – both natural and man-made – appears to prevent a ground-mounted vertical from achieving its full performance potential. Therefore, the elevated location of a vertical monopole – for example, a rooftop – becomes a better location. The higher location is especially apt to the compact, multi-band vertical monopoles produced by many commercial companies.

A second reason for elevating a vertical antenna is the presence of nearby noise sources such as machinery and other instruments that create RF from sparks. Much of this noise is vertically polarized, but hugs the ground in a surface wave. Elevating a vertical can often, but not always, reduce the noise level from these sources. Since noise sources can be very complex, the tactic is not universally successful, but it is worth a try in noisy urban areas.

*d. What makes a monopole's radial plane a ground plane?* A ground plane, then, is simply the completion of the monopole, in effect making it a dipole with a lower half that yields little or no radiation. It only becomes a ground plane when in close proximity to or contact with the earth itself. As the numerous examples have shown, one effect of contact with the earth is a higher feedpoint impedance value, which most analysts have traditionally interpreted as being the sum of the antenna's natural impedance and something called ground losses.

There may be a better way to think about the ground than as a loss-center. This view gives us no idea of how the losses occur. We think of the ground as a big resistor spread out over some amorphous surface area. The picture, of course, makes no sense whatever.

A better way to think about the earth's surface is as a large area that is a semiconductor. A semiconductor is defined in solid state electronics as a material with neither the high conductivity of the best metals nor the low conductivity of the best insulators. What is in between is a broad territory.

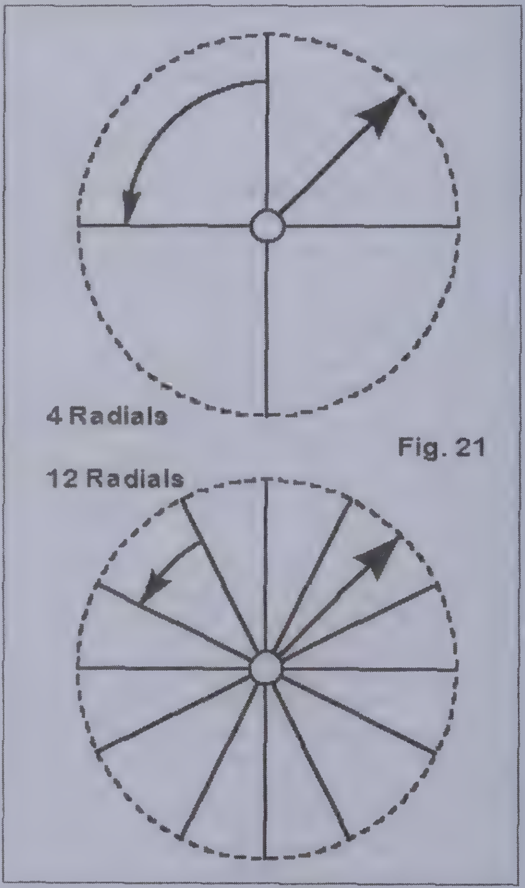


**Fig. 21**

Placing a monopole with a radial plane in the air sets it into a very effective insulating medium. Under these conditions, the fields from the individual radials combine to yield a net of no field at all – assuming a symmetrical radial pattern. If we place the same radial plane in the earth, we cannot talk about fields until we examine all of the conducting material making up the plane. We may insulate the radials, but that does not change anything, except in the local area of the insulation: the radial current yields a field that instantly becomes a current in the adjacent conducting medium. Because soil may be composed of particles, some of

What forms the plane of a vertical monopole when the radials are in the earth is the entire region about the monopole, as suggested in **Fig. 21**.

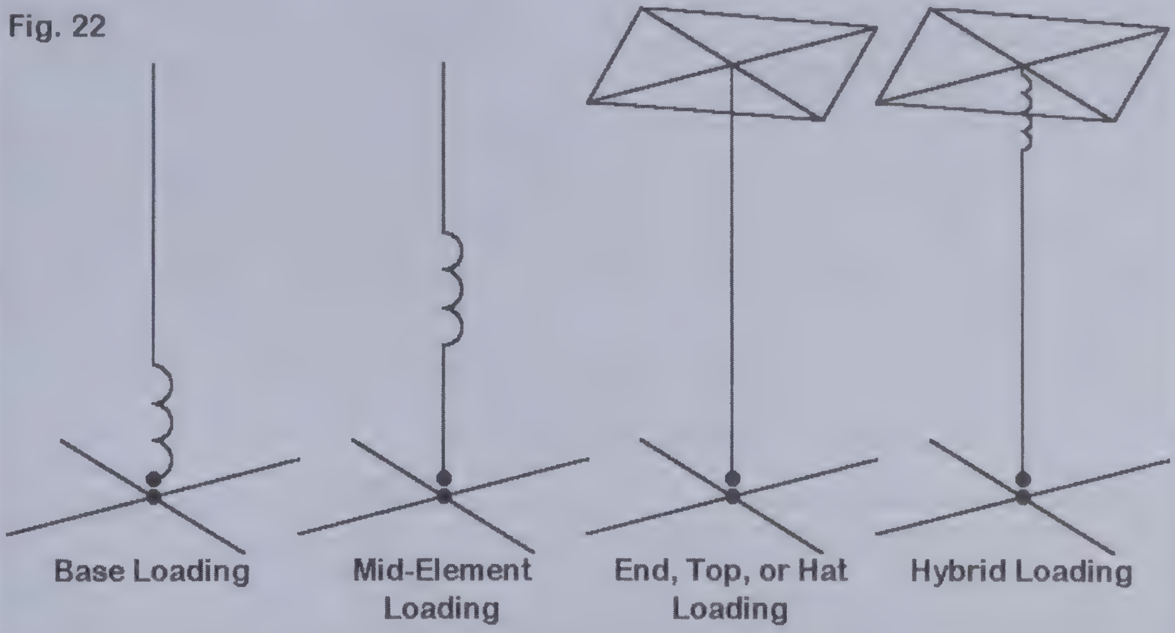
The outline of the region is only a dotted line, because the region has an indefinite boundary. The radial lengths actually show little modeled difference in performance over a 25% change in length, whereas the length of the vertical in air is critical to resonance. Likewise, the lengths of radials that are away from the earth also have a much more marked affect on resonance. Burial of the radials is unnecessary for the earth itself

which conduct and some of which insulate, the overall situation of a surface radial plane is a mix of fields and currents, both of which are detectable and measurable.

to become part of the plane, since radials very close to the ground show the same effects.

Increasing the number of radials in the earth increases the role of high conductivity material in forming the radial plane of the antenna. This shows up not only as increased gain, but as well in a tighter correlation in the feedpoint impedances between the free space and the at-ground versions of the same structure.

Fig. 22



### 7. How can we make a short vertical work well?

For the 40-meter band down through 160 meters, many of us cannot erect a full-size vertical, even of the quarter wavelength variety. So we look for ways to shorten the antenna. **Fig. 22** shows the most common methods: a base-loading inductor, a mid-element loading inductor, a top hat, and a hybrid of inductance and a hot. We shall skip the hybrid, since it should be reserved for mobile use, when the antenna length is super-short.

The loading methods present us with a dilemma. The best method electrically is the most difficult to implement mechanically. Loading coils are fairly straightforward, but the top-loading hat is a heavy wind-catcher. Nonetheless, let's look quickly at some facets of hat loading.

To examine the various loading schemes, I took a full-size 40-meter radial-plane monopole within 0.1' of earth using 16 radials for the test. I then reduced the height to 1/2 full size without changing the radial system. Next, I introduced various loading methods. The base load called for 282.2Ω or 6.28μH. The mid-element load called for 456Ω or 10.15μH. I assumed for the test a Q of 300 as an achievable intermediate range value. The top-hat consisted of four 0.25" diameter spokes, each 9.1' long. In the table below, the gain is relativized to a value of 0 dB for the full-size monopole, since absolute gain figures for near-earth monopoles have not been fully validated.

| Antenna | Relative Gain dB | TO Angle degrees | Resonant Source Impedance Ω |
|---|---|---|---|
| Full-size | 0.00 | 26 | 38.8 |
| Base-loaded | -3.03 | 28 | 18.5 |
| Mid-el. load | -1.52 | 28 | 21.3 |
| Hat-loaded | -0.47 | 27 | 24.7 |

The table should contain no surprises, relative to preconceptions we tend to hold about vertical antennas. However, the difference in relative gain between the base-loaded and the mid-element-loaded monopoles ought to have taken us by surprise. Free space models and models of dipoles using center-loading compared to mid-element loading show far less differential in gain, in fact, too small a differential to make a difference in use. Because mid-element coils have a much higher resistive loss for the same Q, due to the necessity of using larger values of inductive reactance, the overall losses tend to nearly equalize with those of a center-load antenna.

What produces the differential in gain between the base-loaded and the mid-element-loaded monopoles is the proximity of the loading system to the earth and to the right angle plane. Mutual coupling between parts or (or segments of, in models) the main element and the radials differs between the two cases far more than with a linear dipole using center-loading or mid-element-loading inductive reactances. It is thus sound for mobile whips to place loading coils as high as possible.

The higher gain and source impedance of the hat-loaded model relative to the other forms of loading is clearly apparent. What is less well understood is that a hat may be composed of any number of spokes and that these spokes may be used alone or with a perimeter wire connecting their tips. **Fig. 23** shows the results of a study I did with a 3 MHz monopole and hats of both types. Since the effective length of a spoke + perimeter wire is the length of the spoke plus approximately half the length of the wire connecting two tips, the spoke length of the perimeter system starts and remains shorter than using spokes alone. The two systems converge at about 60 spokes or so, beyond which, the radials simulate a solid disc.

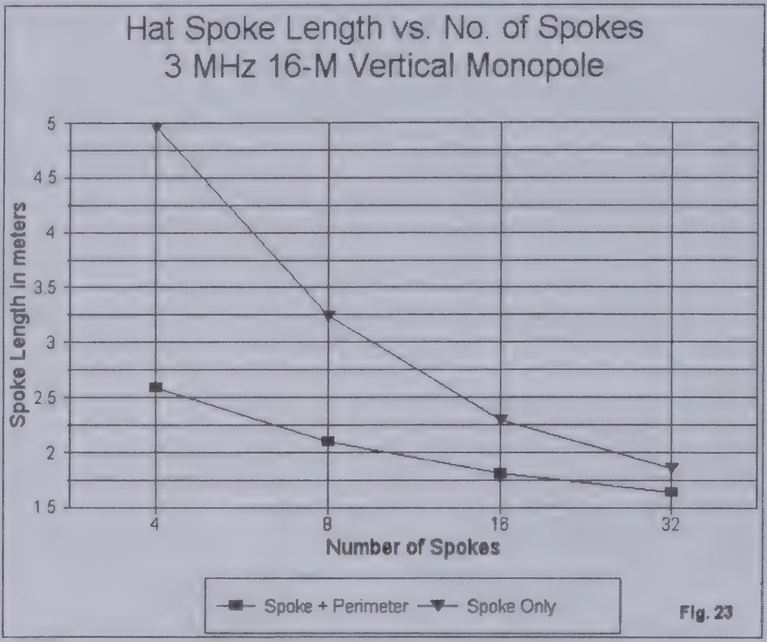


Fig. 23

**Fig. 24** shows modeled SWR sweeps across 40 meters for the antennas earlier tabulated. Each curve is referenced to the antenna's resonant impedance at 7.15 MHz. Of course, the full-size antenna shows the broadest SWR curve, followed closely and desirably by the curve for the top-hat model.

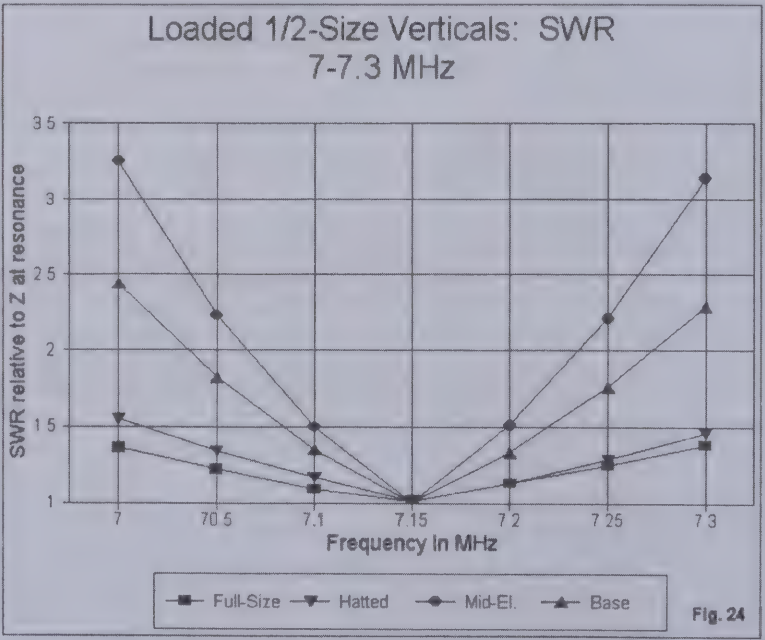


Fig. 24

I have on other occasions already warned you to be ready for surprises, for example, in connection with verticals over different soil types. Here is another case. The narrowest operating bandwidth of the collection occurs with the mid-element-loaded model, not the base-loaded model, despite the reputation of mid-element-loading for providing a wider operating bandwidth than base loading.

Every radial-plane vertical monopole placed close to or on the earth holds the potential for surprises, including the surprise of working quite well. The worst case of our collection, the base-loaded model, is down by only 3 dB relative to a full size monopole, which amounts to just about 1/2 S-unit.

We encounter similar surprises when analyzing shortened vertical dipoles. We can still obtain very usable performance from a vertical dipole as small as 25% full length. The trick is to minimize losses in both the loading assembly and in the connections associated with low-impedance terminals.

**Fig. 25** shows several methods of loading a vertical dipole. Evident are the familiar center and mid-element loading systems that we have already noted. Also at the bottom of the sketch is the Moxon short-radial-plus-reactance system, which has come in for debate. All of these systems are quite usable, even if proponents of various systems cannot fully agree on their relative merits.

The top systems are examples of double hats, one on each end of the dipole, which remains center-fed. Shortening elements by equal amounts at both ends through the use of hats having any number of radials is a tried and true technique for either vertical or horizontal dipoles. It deserves a bit more attention.

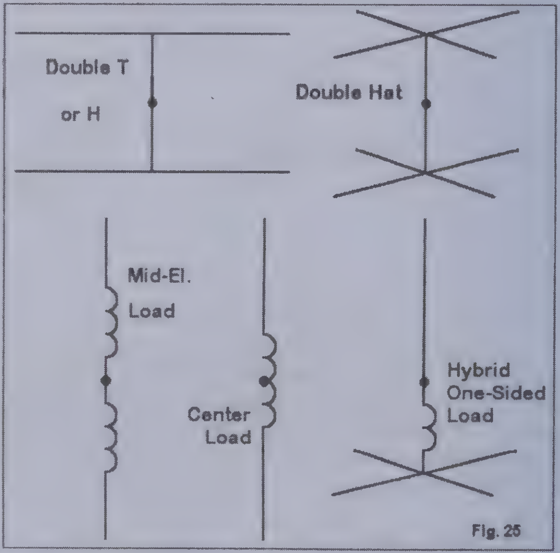


Fig. 25

As an experiment, I designed a 7 MHz vertical dipole about 1/4 normal length: 17.5' long, composed of 1.25" diameter aluminum, which might be a typical ham installation. The base of the antenna was 4.5' above ground, with the top at 22' up, a workable assembly for most sites. Then, I modeled four different ways of loading the antenna:

1. Center loading inductor: 1201Ω or 27.3µH, with a 4-Ω series resistance for a Q of 300.

2. Mid-element loads at about halfway between the center feedpoint and the ends, each 1096Ω or 24.9µH, with a series resistance of 3.65Ω for a Q of 300.

3. Top and bottom hat loads composed of four spokes, each 9.35' long, and a perimeter wire, with all aluminum hat assembly wires 0.125" in diameter.

4. Top and bottom "Tee" wires of 0.125" diameter aluminum, each wire 46.6' long.

The results are in the table, with the gain of each antenna version referenced to a value of 0 dB for the double-Tee model.

| Antenna | Relative | TO Angle | Feedpoint Z |
|---|---|---|---|
| | Gain dB | degrees | R +/- jX Ω |
| Center load | -2.3 | 26 | 11.6 - j 0.1 |
| Mid-el. load | -2.1 | 26 | 18.0 + j 0.1 |
| 4-spoke hat | -0.3 | 27 | 28.2 - j 0.3 |
| Double-Tee | 0.0 | 27 | 26.9 + j 0.4 |

The inductively loaded versions of the antenna are significantly down in gain from the hatted versions. Most of the loss is in the inductors of finite Q. If truly lossless inductors could be used, the total spread of gain would amount to about 0.5 dB. However, the center-load antenna impedance would be about 7.5Ω, while the mid-element-loaded version would be about 18Ω. The higher feedpoint impedances shown in the chart reflect the losses in the inductors.

Between the hatted versions there is little to choose except the most convenient installation method for a particular site. As shown in **Fig. 26**, the gain difference reflects a slight ovalizing of the double-Tee pattern in the direction of the wire ends. (The very slight departure from a circular pattern also shows up in a single Tee monopole over a ground plane. A full 1/4λ monopole over a 16-radial plane at ground level, incidentally, shows about the same gain and take-off angle as these slightly elevated vertical dipoles.) Other end-loading arrangements are possible. These samples simply demonstrate the feasibility of the technique.

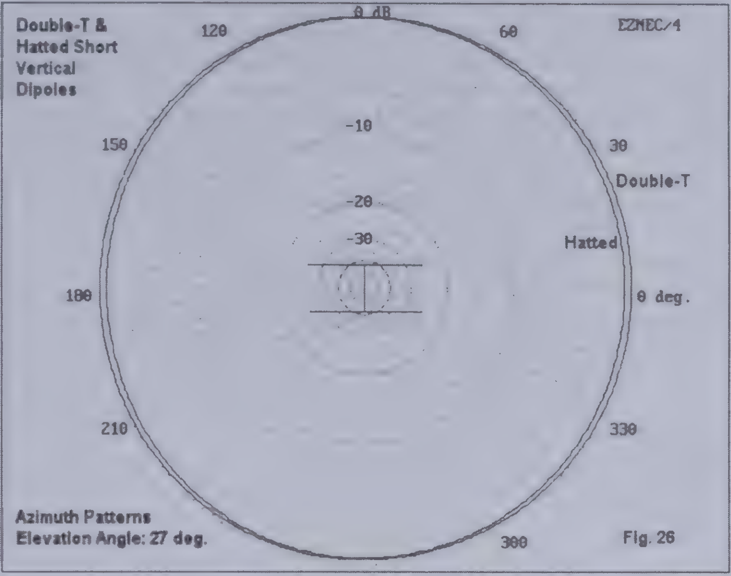


Fig. 26

Edited by W1HUE

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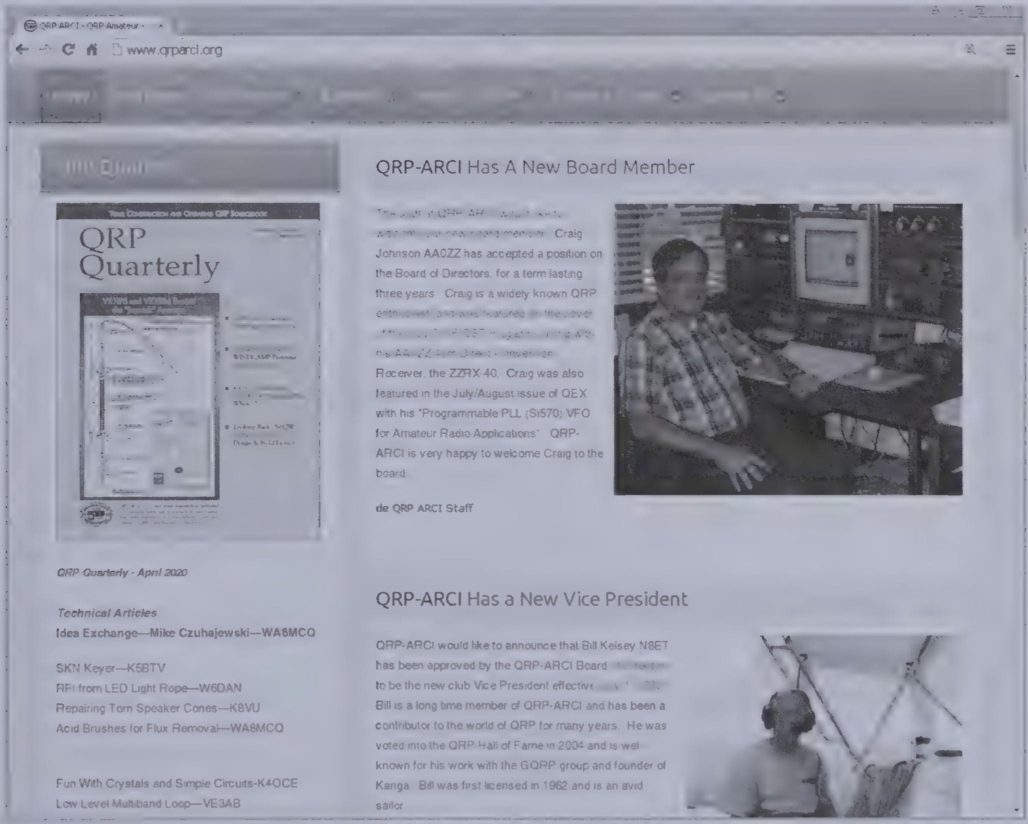


QRP-ARCI Has A New Board Member

Craig Johnson AA0ZZ has accepted a position on the Board of Directors, for a term lasting three years. Craig is a widely known QRP

Receiver, the ZZRX-40. Craig was also featured in the July/August issue of QEX with his "Programmable PLL (Si570) VFO for Amateur Radio Applications". QRP-ARCI is very happy to welcome Craig to the board.

de QRP ARCI Staff

QRP-ARCI Has a New Vice President

QRP-ARCI would like to announce that Bill Kelsey N8ET has been approved by the QRP-ARCI Board to be the new club Vice President effective

Bill is a long time member of QRP-ARCI and has been a contributor to the world of QRP for many years. He was voted into the QRP Hall of Fame in 2004 and is wel known for his work with the GQRP group and founder of Kanga. Bill was first licensed in 1962 and is an avid sailor.

*QRP Quarterly - April 2020*

*Technical Articles*

Idea Exchange—Mike Czuhajewski—WA8MCQ

SKN Keyer—K5BTV

RFI from LED Light Rope—W6DAN

Repairing Torn Speaker Cones—K8VU

Acid Brushes for Flux Removal—WA8MCQ

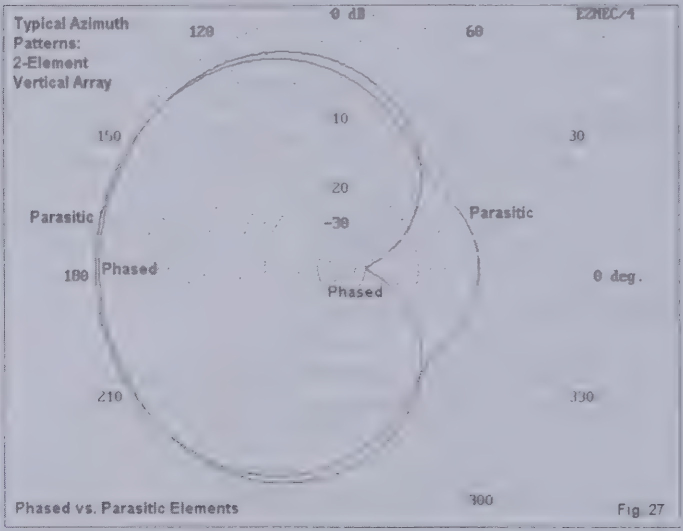
Fun With Crystals and Simple Circuits-K4OCE

Low Level Multiband Loop—VE3AB

## *8.* How can we make verticals directional?

I have not stressed any particular gain figure for the sample vertical antenna systems shown because actual gain will depend on too many variables for any generalized figure to make any sense. 1/4λ monopoles with ground plane at or near the earth's surface require large numbers of radials for maximum efficiency. Slightly elevated radial systems require close attention to symmetry to avoid pattern distortion. Gain also varies with the soil in the immediate antenna location for near-ground monopoles. The gain of both monopoles with highly elevated radial systems and vertical dipoles depends as well upon the soils in the Fresnel or reflection zone.

Whatever our initial gain for a single vertical antenna, we can improve upon it by applying standard techniques for creating directional antennas from two or more vertical elements. In the process, we may gain a significant reduction of gain to the rear of the array of elements. In short, we may create vertical beams.



The two most common techniques for creating vertical arrays involve either phasing the current among the elements or using parasitic elements. **Fig. 27** shows in a broad way the differences in anticipated performance. Phased elements can deliver a deep null to the rear, often exceeding 30 dB relative to the maximum forward gain. However, the deep phased array null extends only over about 60 of the horizon. The front-to-back ratio of parasitic arrangements rarely exceeds about 10-12 dB. In exchange for accepting a lesser front-to-back ratio, the builder of parasitical arrays has a simpler building task, since phasing techniques require extensive calculations and careful construction.[8]

A 2-element array gives a broad forward lobe. Even with beam reversal techniques, much of the horizon remains outside of the main lobes. The simplest technique for covering the entire horizon with fixed vertical elements is to use three in a triangle and to switch them. Let's briefly examine a full-size and a shortened array of vertical dipoles to see what is involved.

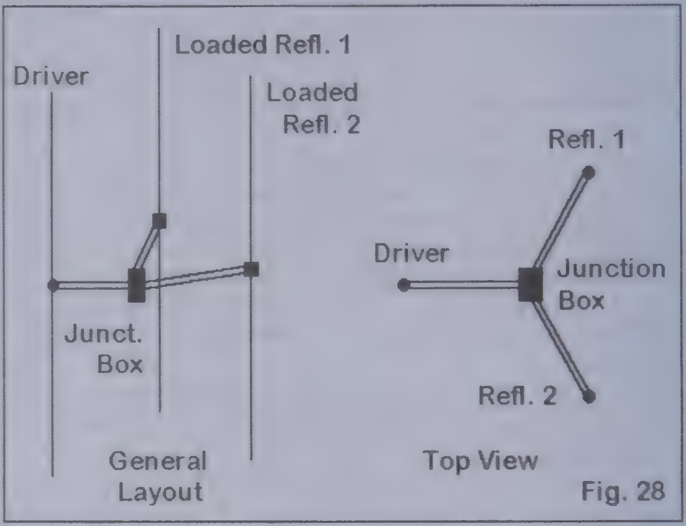
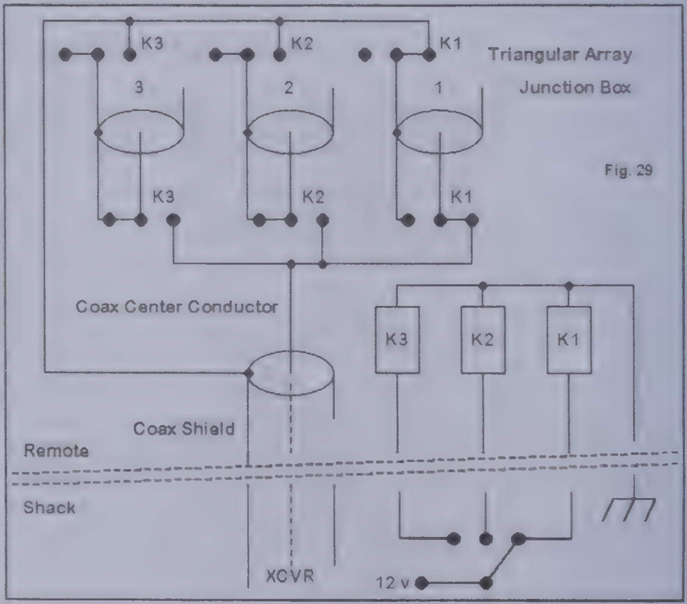


**Fig. 28** sketches the outlines of three vertical dipoles set 10' above ground at their bases. For 40 meters, the dipoles are 65.9' long, and for 30 meters they are 46.3' long. The 40-meter triangle is 22' on a side, while the 30-meter triangle is 15.5' on a side. From each dipole, a 50-Ohm coax stub (RG-213, VF=0.66) extends to a center junction box. The 40-meter stub is 16.4' long, while the 30-meter stub is 11.7' long.

For each direction, one stub is connected to the shack feedline. The other two stubs are shorted to form inductive reactances that electrically lengthen the elements to proper reflector size. A typical switching box is shown in **Fig. 29**.



The result is a 3-direction switchable array that can cover the entire horizon, as shown in **Fig. 30**.

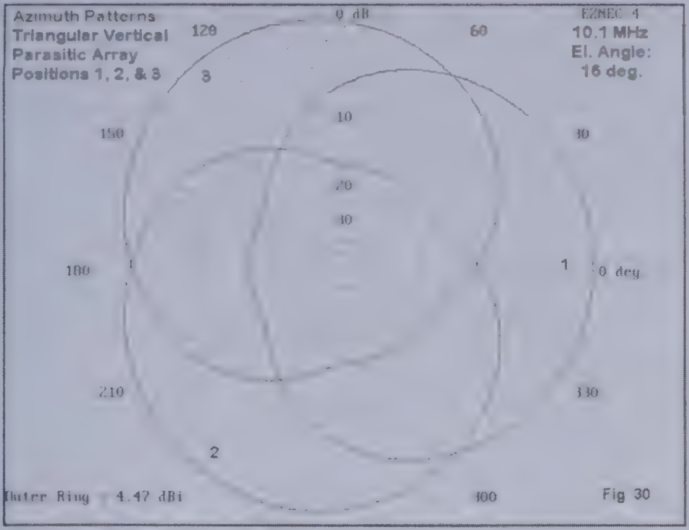


Fig 30

The array gain is about 3 dB greater than a single vertical dipole at the same height. The dual reflector system provides about 12 dB of front-to-back ratio. Although the array is about as simple as one might imagine, its chief drawback is finding supports for the tall vertical dipoles.

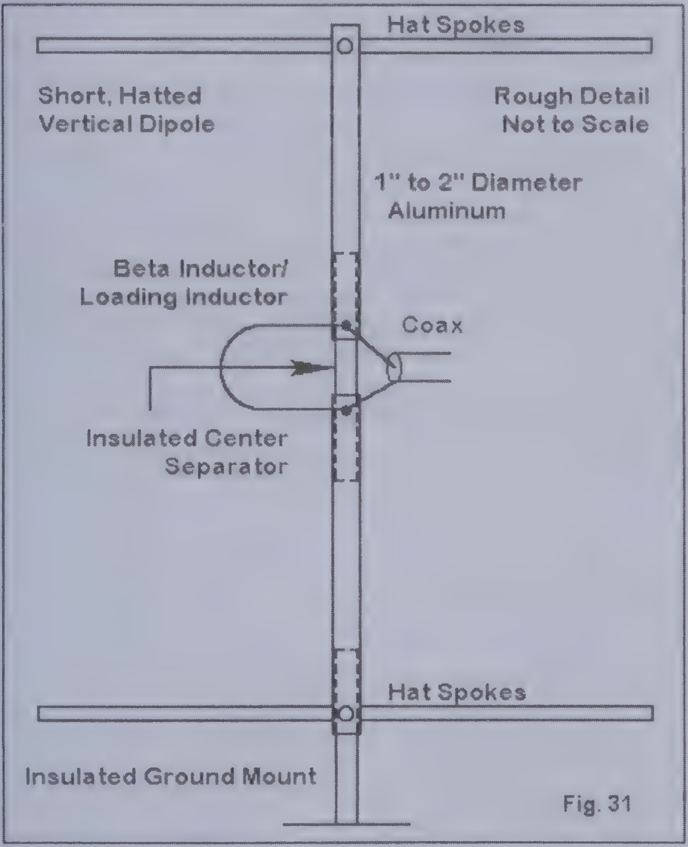


Fig. 31

We can also make an array from the short hatted vertical dipoles we briefly examined, using essentially the same 22' per side spacing of elements employed for the full size array. However, the elements can be supported from below, as suggested in **Fig. 31**. The sketch also hints at another change in arrangements.

The feedpoint impedance for the driven element will be about 25Ω. By setting the length of the vertical (or of the hat spokes) a bit short, the driver impedance becomes capacitively reactive. If we introduce a hairpin (a shorted transmission line section) or a coil across the feedpoint, we effect a beta match to bring the impedance to 50Ω for coaxial feed.

We leave the beta hairpins or coils across each feedpoint. Using the same switchbox that we used for the full sized array, we switch in a 1/4λ section of coax from the box to the driver. The 1/4λ sections from the other elements are shorted at the box, creating an open circuit at the element. The hairpin or coil now becomes a small inductively reactive load, electrically lengthening the element for reflector service.

Once more, we can cover the horizon with a 3-position switch. The gain of this short array is about 2.5 to 3 dB over the gain of a single short vertical, with better than 12 dB front-to-back ratio. Although the short array cannot match the forward gain of the much taller vertical array, it can certainly be useful with respect to adding a directional dimension to one's operating.

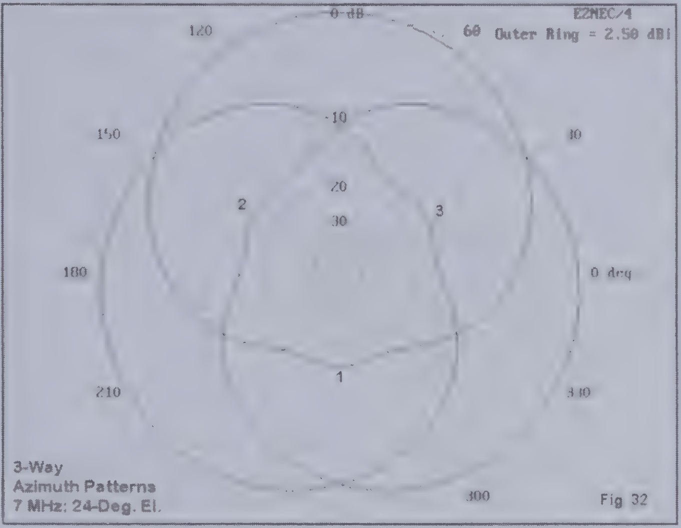


Fig 32

More complex arrays are certainly possible using five elements for a four-cornered, three-element parasitic beam system. The center element can be a voltage-fed 1/2λ tower used to support upper HF beams, with the guy wires used for parasitic elements under proper switching conditions for electrically lengthening and shortening them. In fact, directional vertical arrays for lower HF use are limited only by the electrical and mechanical ingenuity of the builder.

### 9. How can we make verticals out of wires that are mostly horizontal?

Vertically polarized radiation patterns need not come only from vertical elements. We can construct vertically polarized antenna from wire loops, generically known as SCVs (self-contained vertically polarized large wire loops). **Fig. 33** shows the out line of several different types.

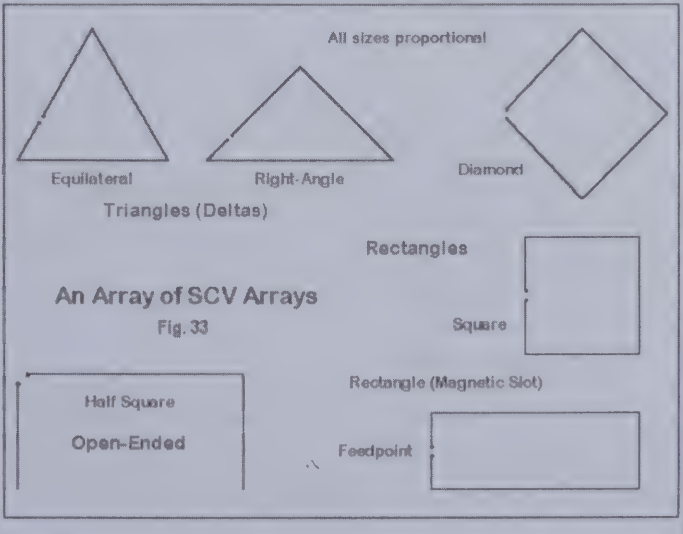
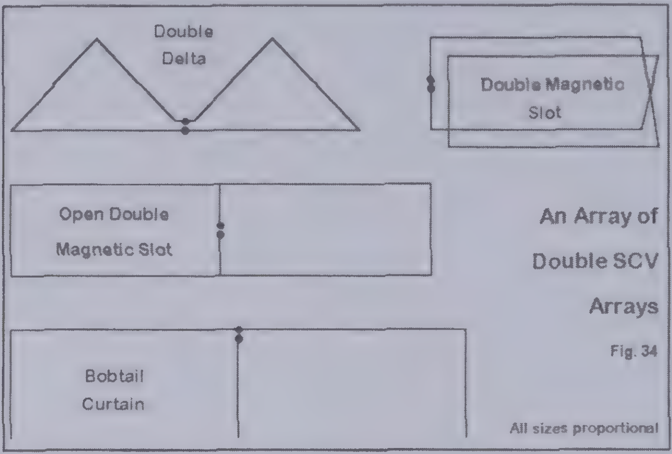


Fig. 33

Each of these single loop versions of the SCV produce a bi-directional pattern, ranging from a broad oval for the delta loops to a peanut-shaped pattern for the rectangle and the half square. All of the antennas have a feedpoint 1/4λ from the top center, which maximizes vertically polarized radiation. The connecting wire between the feedpoint and a point exactly opposite it on the opposing side structure acts as a phasing line by being a 1/2λ line in which the current phase reverses. The voltage and current at the opposing points are equal in magnitude and opposite in phase, creating a pair of quarter wavelength verticals in phase. Radiation is broadside to the array. The antennas are self-contained and require no ground plane or soil treatment beneath the antenna structure.



An Array of Double SCV Arrays

Fig. 34

If space permits, the builder can develop "double-wide" version of some SCV configurations for additional gain and directivity, as shown in **Fig. 34**. Some names originally given to SCV configurations are misnomers. The table below provides a very general indication of relative performance by listing the gains of some common configurations at 7 MHz with a 50' maximum height.

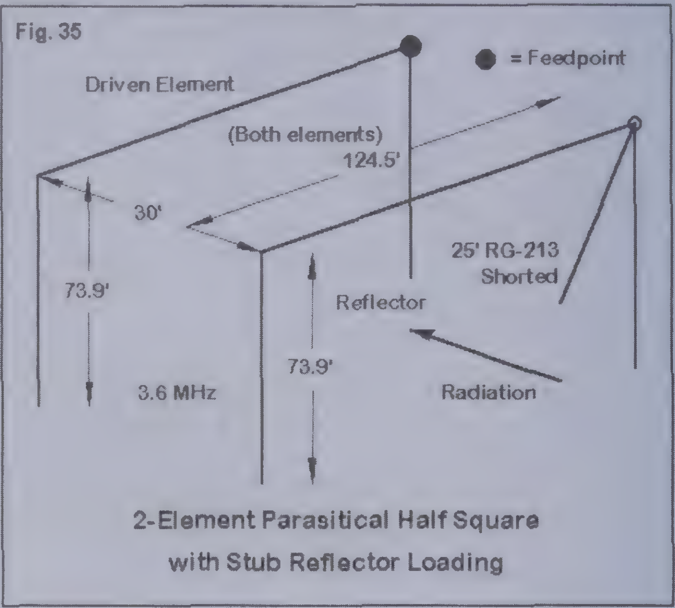
| Antenna Name | Gain dBi | Front-Side Ratio dB | TO Angle degrees | Feed Z Z=RΩ |
|---|---|---|---|---|
| Equi. Delta | 1.5 | - 3 | 18 | 135 |
| R.-A. Delta | 1.9 | - 5 | 20 | 60 |
| Dbl R-A D. | 3.7 | -12 | 20 | 40 |
| Sq. Quad | 1.6 | - 4 | 18 | 145 |
| Dia. Quad | 1.5 | - 4 | 16 | 135 |
| Rect. (MS) | 3.0 | -12 | 17 | 15 |
| Dbl MS | 3.3 | -12 | 17 | 80 |
| Open DMS | 4.5 | -25 | 16 | 30 |
| Half Square | 3.4 | -15 | 18 | 65 |
| Bobtail | 5.0 | -28 | 18 | 40 |

In the charted figures, not all of the antennas are at optimal height. Each type of SCV has an optimal height range. Below that range, ground interactions reduce gain significantly; above that range, the gain of the lowest lobe drops as a new higher-angle second lobe forms. Since SCV's are employed to take advantage of the low angle of radiation with rejection of higher-angle QRM and QRN, the secondary lobe actually reduces the desired performance.

Two cautions about SCVs are necessary to get the most from them. First, do not have improper expectations of them. They are capable of gain and directivity relative to a vertical monopole or a vertical dipole. However, that gain is not the gain of a horizontal dipole that is at least 1/2λ above ground. Instead, because the elevation pattern is typically the low-angle, single lobe pattern associated with monopoles, wise users expect better signal-to-noise ratios from DX signals, but not necessarily a more power signal.

Second, design carefully. Casual design and construction of an SCV may yield disappointment. Besides having an optimal height range, each SCV type also has an optimal shape for maximum gain. In some cases, the ratio of the vertical to horizontal measure may vary with frequency.[9]

Fig. 35

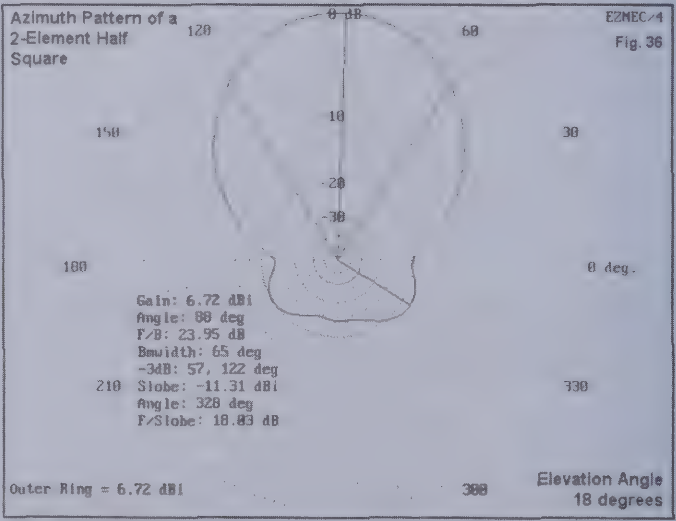


2-Element Parasitical Half Square with Stub Reflector Loading

Although any of the basic SCVs is already an array of 2 elements phased, it is fairly straightforward to create a parasitic beam from a pair of SCVs. **Fig. 35** shows an example, a 3.6 MHz reversible half-square pair. The length of coax from the reflector is match with a similar line from the driver feedpoint to a center junction box. By switching from direct feed to a short, the line changes from a simple feedline to an inductively reactive shorted stub that electrically lengthens the non-driver to reflector status. Similar schemes can be applied to any of the SCVs to obtain a reversible beam.

Azimuth Pattern of a 2-Element Half Square

Fig. 36



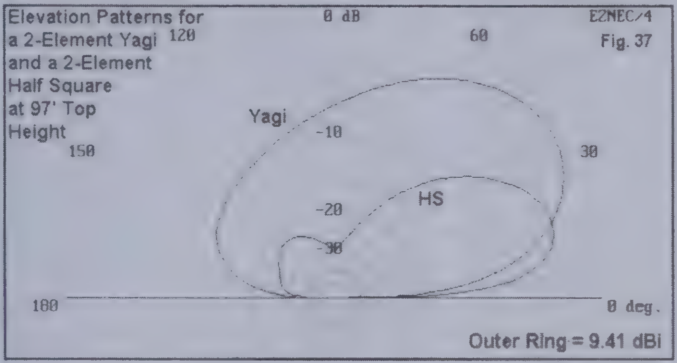
```
Gain: 6.72 dBi
Angle: 88 deg
F/B: 23.95 dB
Bmwidth: 65 deg
-3dB: 57, 122 deg
Slobe: -11.31 dBi
Angle: 328 deg
F/Slobe: 18.83 dB
```

**Fig 36** shows the anticipated performance from such a beam when placed at an optimum height above ground. With a forward gain of about 3 dB over a single half square and a worst-case front-to-rear ratio of over 18 dB, the antenna offers excellent low angle (DX) performance for the amateur with the space and supports for the array. This last statement presumes, of course, that we point the antenna in the right directions.

Because SCVs require only wire and accessories, they form an attractive alternative for some locations to erecting complex aluminum structures. For each band, their height requirements are modest compared to the height needed for an equally effective horizontal antenna. On the other hand, we still need some tall trees or structures to hold up the wire.

### *10.* Just how "good" is a vertical?

The answer to this question depends on what is going to count as good. If what we want is an antenna for the lower HF bands that maximizes low angle radiation and reception to yield a higher signal-to-noise ratio—but not necessarily more power—for DX operation, then one or another of the vertical antennas we have surveyed may prove a superior candidate. For example, the half-square beam we have just examined will outperform a Yagi placed at the same 95' maximum height relative to DX, although not for shorter skip contacts. **Fig. 37** tells the story.



The Yagi has more raw gain, but most of its power is at too high an angle for most DX, since the antenna height is only about 1/3λ. The half-square beam at the same height promises more power at the lower angle.

More modest installations can expect lesser performance, but similar patterns of performance: better contacts over longer paths and weaker signals closer in. However, even these installations must use careful construction and well-designed structures to achieve all that a vertical can give. For a monopole that is ground-mounted, four radials will yield something, but 30 radials will yield a lot more—and 60 or more will yield the most that the antenna can give.

Installation also requires close attention to surroundings. Ground and near-ground mounted verticals tend to be susceptible to signal absorption by ground clutter and to noise from man-made sources. A clear field for at least a wavelength—and hopefully a lot more—is necessary for best results. Moreover, a naturally quiet location is a big help.

For the city and suburban dweller, an elevated mounting may be best, if feasible. A rooftop at least 20 to 30 feet up can reduce local noise and improve signal strength on both transmission and reception, especially for multi-band trap verticals. However, if the antenna is a 1/4λ monopole, one must use a radial system. I personally recommend at least four radials for each band (using something like multi-wire flat rotor cable, or similar, or a radial fan of single wire radials spread across the roof) arranged as symmetrically as possible.

Elevated city and suburban installations must give attention to system grounding for lightning and static charge protection, but for most elevated verticals, providing RF isolation from the ground line will prevent diversion of signals into the ground. Simple RF chokes of sturdy construction usually suffice.

Whether circumstance forces us to use a vertical antenna or whether we choose to use one to achieve certain operational goals, the key to successful construction and operation is a better understanding of how verticals work and how various competing vertical possibilities compare in potential. My goal in these notes has been to cut away some outmoded ways of thinking about verticals, including some downright harmful and ignorant ways of talking about them.

Even when approached with thoughtfulness, vertical installations still remain subject to an array of variables that will normally defy precise analysis short of long-term operating experience. Soils that affect far field patterns are often beyond analysis for most ham installations. Some aspects of the operation of ground planes are undergoing re-analysis and re-measurement. In the interim, certain facets of ground planes are vocally disputed, as if loud voices could make the measurements come out as desired. Alas, we must wait patiently for results to emerge before making any final pronouncements—for example, on how Christman elevated radial systems compare with surface ground plane systems.

That does not mean that we cannot learn more about verticals. And it does not mean that we cannot use them effectively. Clear thinking goes a long way to avoiding that dizzying vertigo that has in the past infected the study and use of vertical antennas.

Edited by W1HUF

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## **Notes** (For all three installments)

1. If you are serious about studying vertical antennas, begin with any recent edition of *The ARRL Antenna Book*, although the information is scattered in many chapters. The ARRL *Antenna Compendium* series has many good articles as well. *The Amateur Radio Vertical Antenna Handbook*, by Paul Lee, N6PL, is by now a classic, as is *All About Vertical Antennas*, by Bill Orr, W6SAI, and Stuart Cowan, W2LX. *Vertical Antenna Classics* from ARRL is a collection of relevant articles. For lower HF applications, the most complete study remains *Antennas and Techniques for Low-Band DXing*, by John Devoldere, ON4UN.

2. The following table may help you appreciate soil differences better. The table represents an adaptation of values found in *The ARRL Antenna Book* (p. 3-6), which are themselves an adaptation of the table presented by Terman in *Radio Engineer's Handbook* (p. 709), taken from "Standards of Good Engineering Practice Concerning Standard Broadcast Stations," *Federal Register* (July 8, 1939), p. 2862. Terman's value for the conductivity of the worst soil listed is an order of magnitude lower than the value shown here

| Soil Description | Conductivity in S/m σ | Permittivity (Dielectric Constant) ε | Relative Quality |
|---|---|---|---|
| Fresh water | 0.001 | 80 | |
| Salt water | 5.0 | 81 | |
| Pastoral, low hills, rich soil, typical from Dallas, TX, to Lincoln, NE | 0.0303 | 20 | Very Good |
| Pastoral, low hills, rich soil, typical of OH and IL | 0.01 | 14 | Good |
| Flat country, marshy, densely wooded, typical of LA near the Mississippi River | 0.0075 | 12 | |
| Pastoral, medium hills, and forestation, typical of MD, PA, NY (exclusive of mountains and coastline) | 0.006 | 13 | |
| Pastoral, medium hills, and forestation, heavy clay soils, typical of central VA | 0.005 | 13 | Average |
| Rocky soil, steep hills, typically mountainous | 0.002 | 12-14 | Poor |
| Sandy, dry, flat, coastal | 0.002 | 10 | |
| Cities, industrial areas | 0.001 | 5 | Very Poor |
| Cities, heavy industrial areas, high buildings | 0.001 | 3 | Extremely Poor |

3. The best compact treatment of soils and antennas is Chapter 3 of *The ARRL Antenna Book*.

4. See *Antennas and Techniques for Low-Band DXing*, by John Devoldere, ON4UN, pages 9-30 to 9-31.

5. Here is a convenient, but neither authoritative nor exhaustive, set of ground types or classifications that may be useful in sorting out various aspects of ones antenna system:

G1. The DC and static discharge ground
G2. Circuitry common buss (ground)
G3. Lightning ground
G4. RF ground
G5. Far field reflective ground
G6. Antenna-completion ground

Only the last type of ground is under discussion, and it does not require THE ground to function. It is in the near field of the antenna, but is not itself the near field ground in the same sense in which we speak of the far field ground. The only time THE ground comes into play is when the antenna-completion ground—or plane—is under, on, or very near THE ground.

6. All models of verticals with ground planes have gone through a thorough development to avoid some modeling pitfalls. They originate with free space dipoles, with their standard 72-Ω feedpoint impedance. Then, the model replaced the lower leg of the dipole with a set of radials (ranging from 2 through 64 in various steps), in each case, with the radial lengths adjust for resonance. At each step, the models were convergence tested (that is, the number of segments per unit length increased in steps) to establish the internal coherence of the model. Models were also checked to assure that the feedpoint represented as closely as possible the maximum current position on the antenna, with the sum of the adjacent segment currents equal to the source current.

7. The notion that a radial-plane monopole has a feedpoint impedance of 36Ω arises from the theoretical exercise of modeling a monopole as a simple vertical element above a perfect ground, thus automatically giving an impedance of 1/2 that of a dipole. In fact, modeling programs will yield the same result, since they create a mathematical image antenna beneath the modeled one. In fact, the source impedance of a real radial-plane monopole varies considerably due to factors not accounted for in the dubious image-antenna calculational convenience. The ratio of diameters of the main element and the radials plays an important role in the feedpoint impedance, as it also does in determining the length of radials for resonance. We obscure these facts with assumptions carried into the field site and also by laying radials and them adjusting the monopole height to achieve resonance. Under these conditions, one rarely if ever achieves maximum current at the feedpoint.

8. The best sources for basic information on phased vertical arrays is *The ARRL Antenna Book*, Chapter 8, and *Low Band DXing*, Chapter 11.

9. More complete details on the SCV family of antennas can be found in a series of article appearing in 1998 and 1999 issues of *The National Contest Journal*. The articles can also be found at my web site:

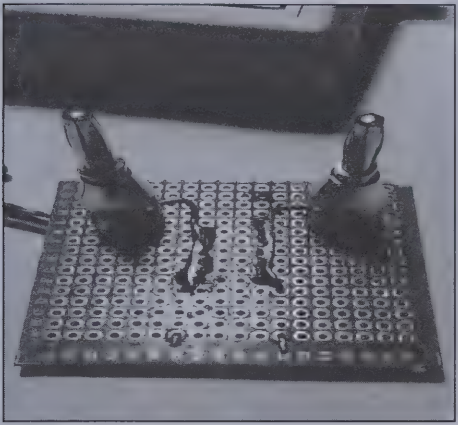
http://www.cebik.com/

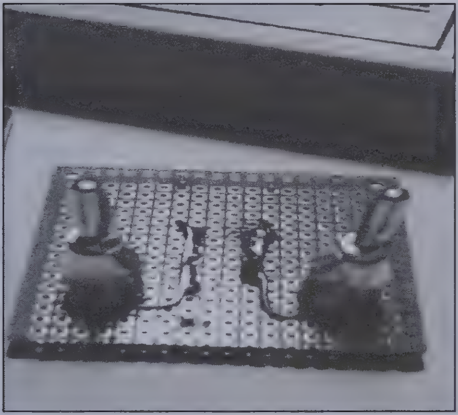
# Projects for Covid-19 Homebound Stir Crazy Relief

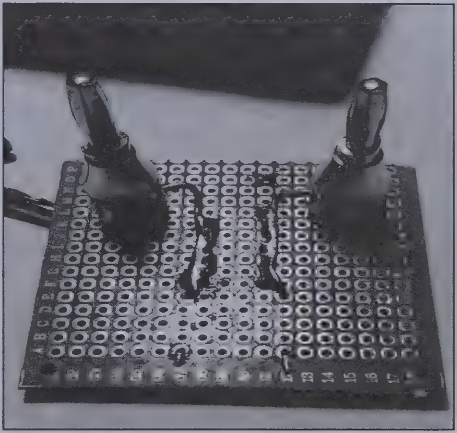
Dr. Donald Sanders—W4BWS
w4bws1@gmail.com

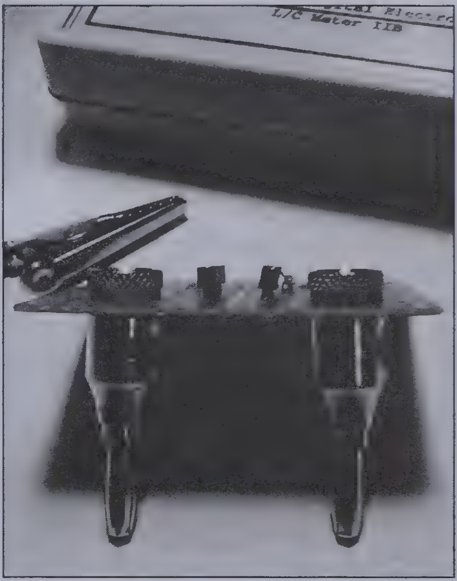
*Project #1* — Component test adapter for AADE capacitor/inductor tester

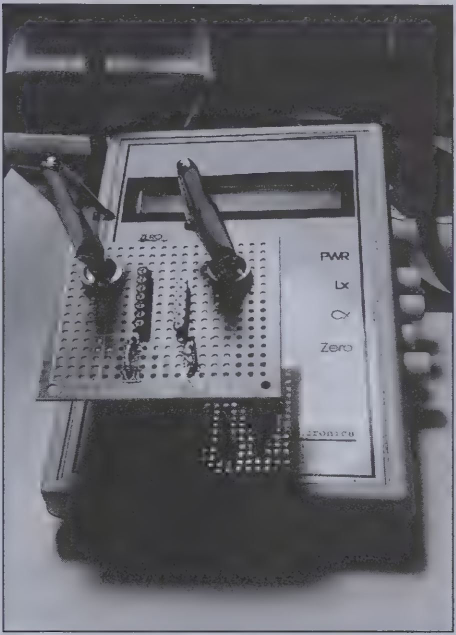
Below are pictures of a test adapter for the AADE II test set:











- There are two strips of header pins on top side, to connect cap or inductor leads. Two wires on top side are connected to strip pins for large components.
- Strip pins are connected to the banana plugs and on top side two alligator clips slide into the banana plugs.
- The banana plugs are from eBay.

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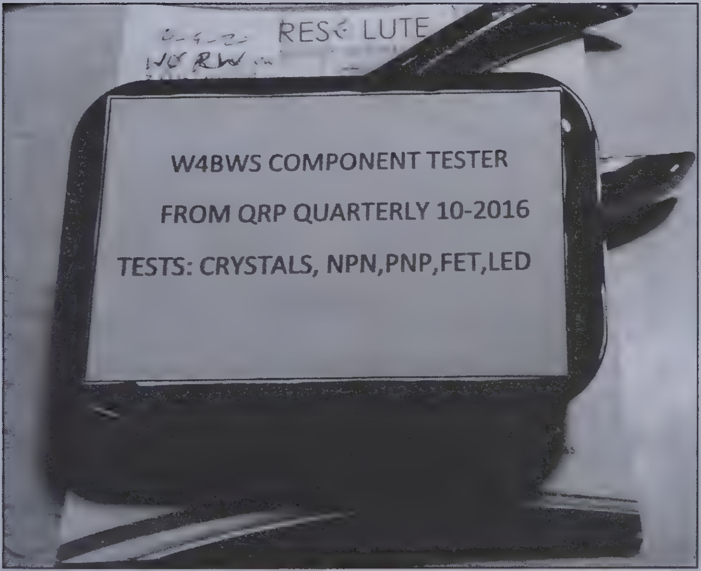
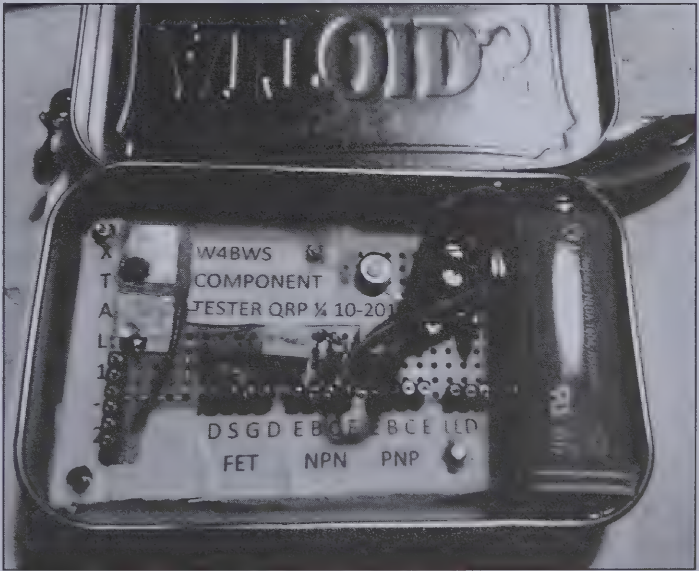
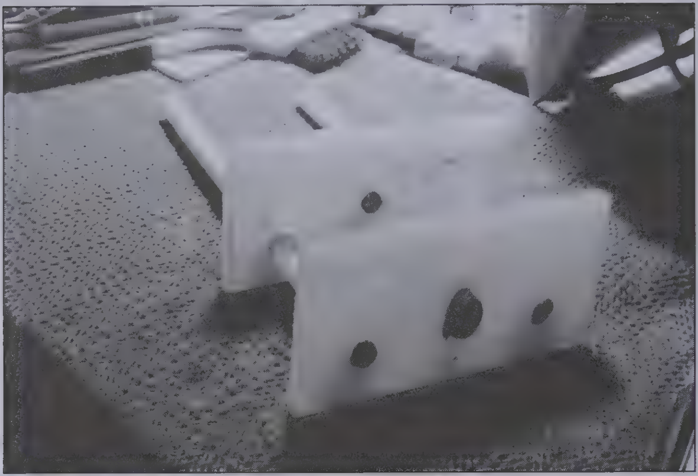
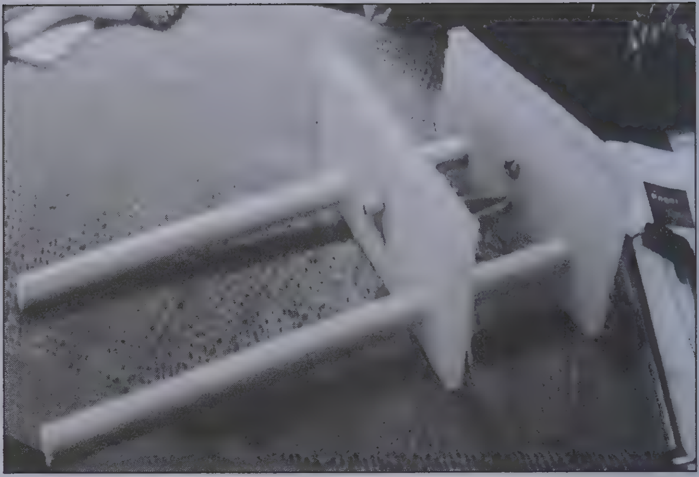
*Project #2* — 5-in-one component tester from *QRP Quarterly* October 2016

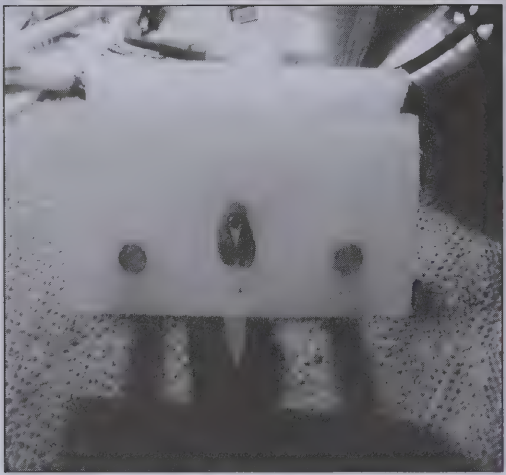


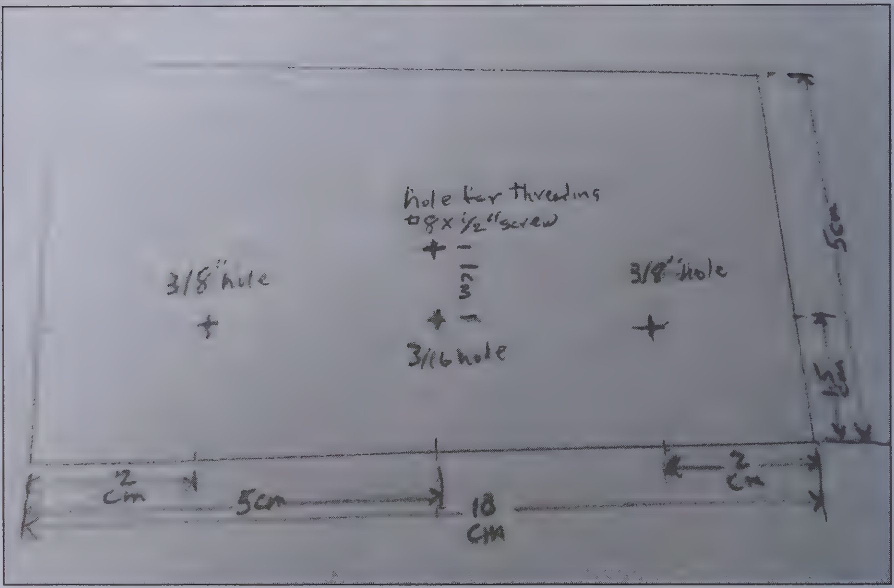


### *Project #3* — PCB holder from Walmart parts









- White cutting board, two wooden dowels, two # 8 screws and nuts, one rubber band. Total cost less than $ 10.

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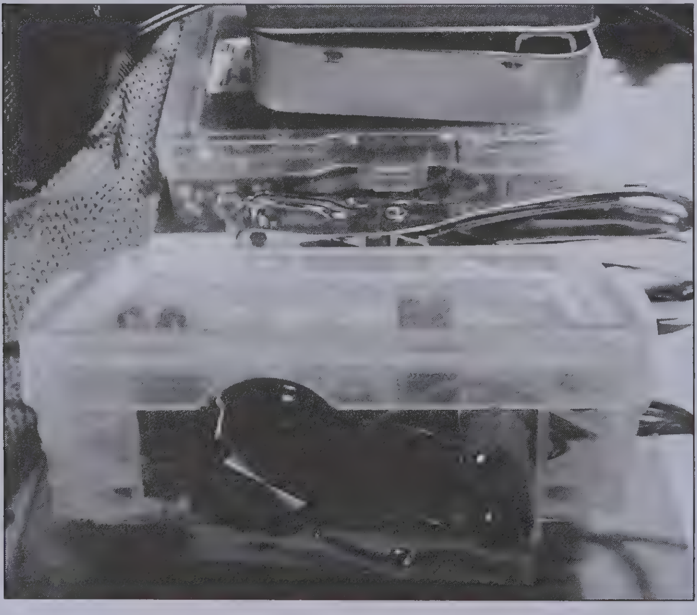
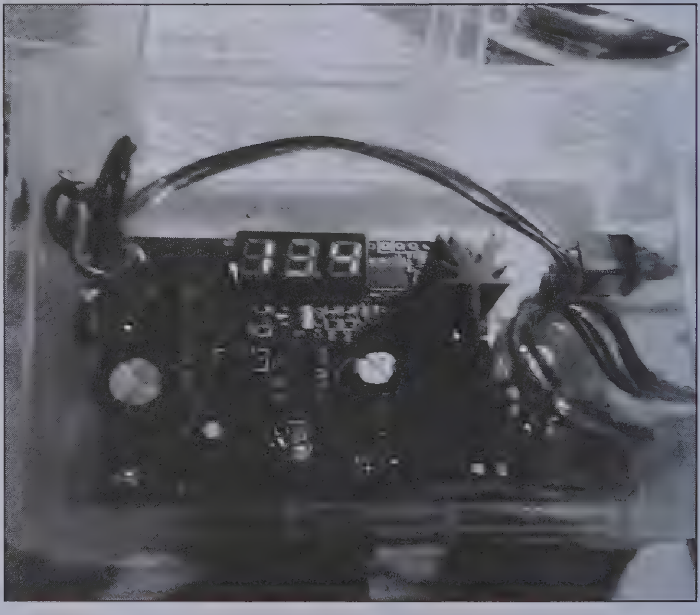
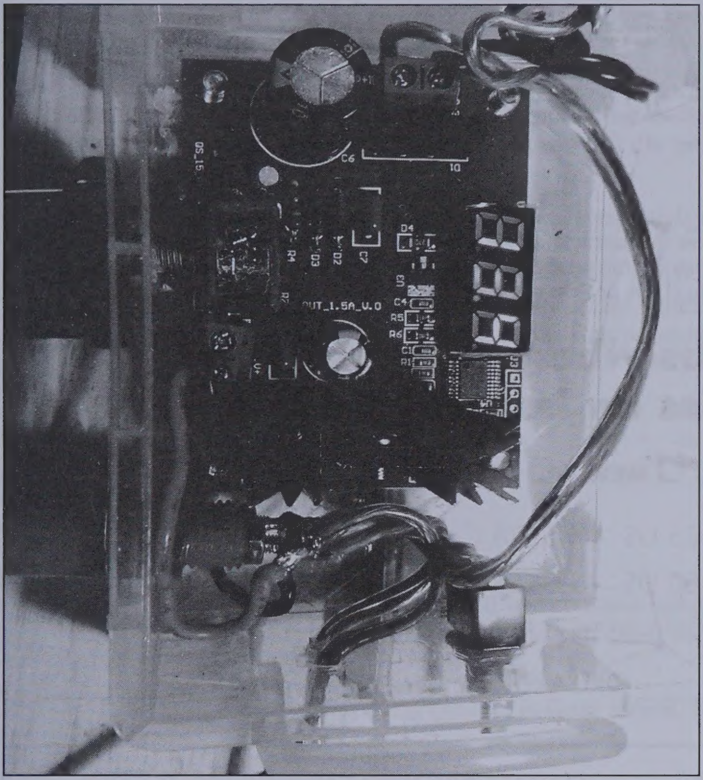
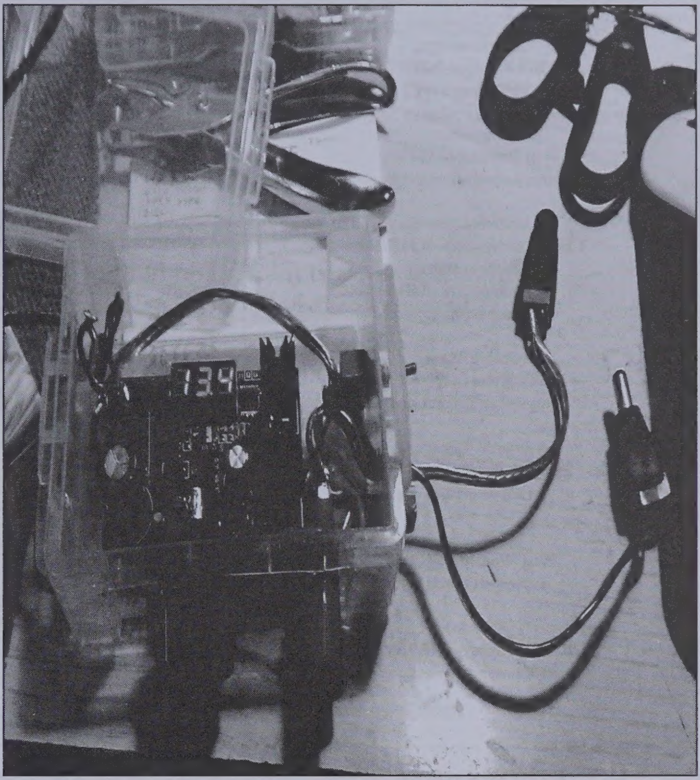
### *Project #4* — Battery charger and small variable power supply





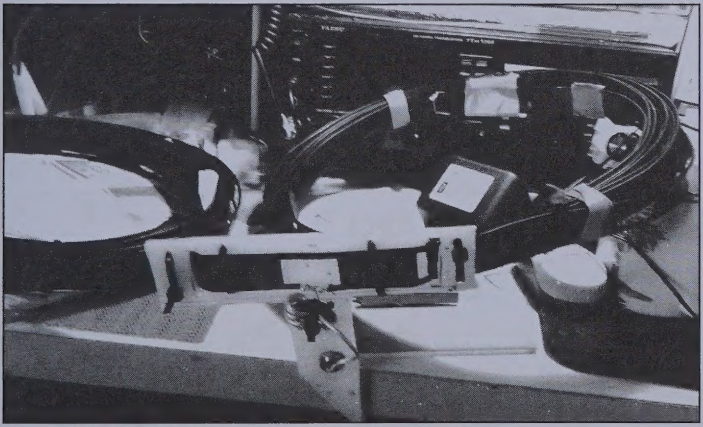
- Plastic crayon holder from Walmart $0.88. PS Module eBay $6.00
- Binding posts, switch, output plug and socket from eBay, about $5.00
- Power supply from Jameco 16 VAC , 1 AMP $16.00

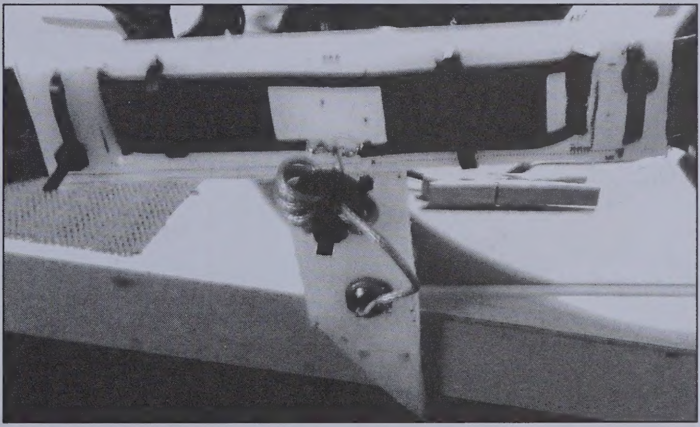




*Project #5* — 40/20 dipole from ARRL

Photos of ready-for-testing antenna. Added toroid common mode balun to interface to 50 feet rg58 coax. Connections will be potted with liquid rubber after tuning. Parts all from junk box.





*Project #6* — Finished my antenna book!

Hope to have it on Amazon in May 2020 and available by direct order as PDF May 1st 2020 by PayPal $7 to my email address. 100+ pages of basic wire antenna information.

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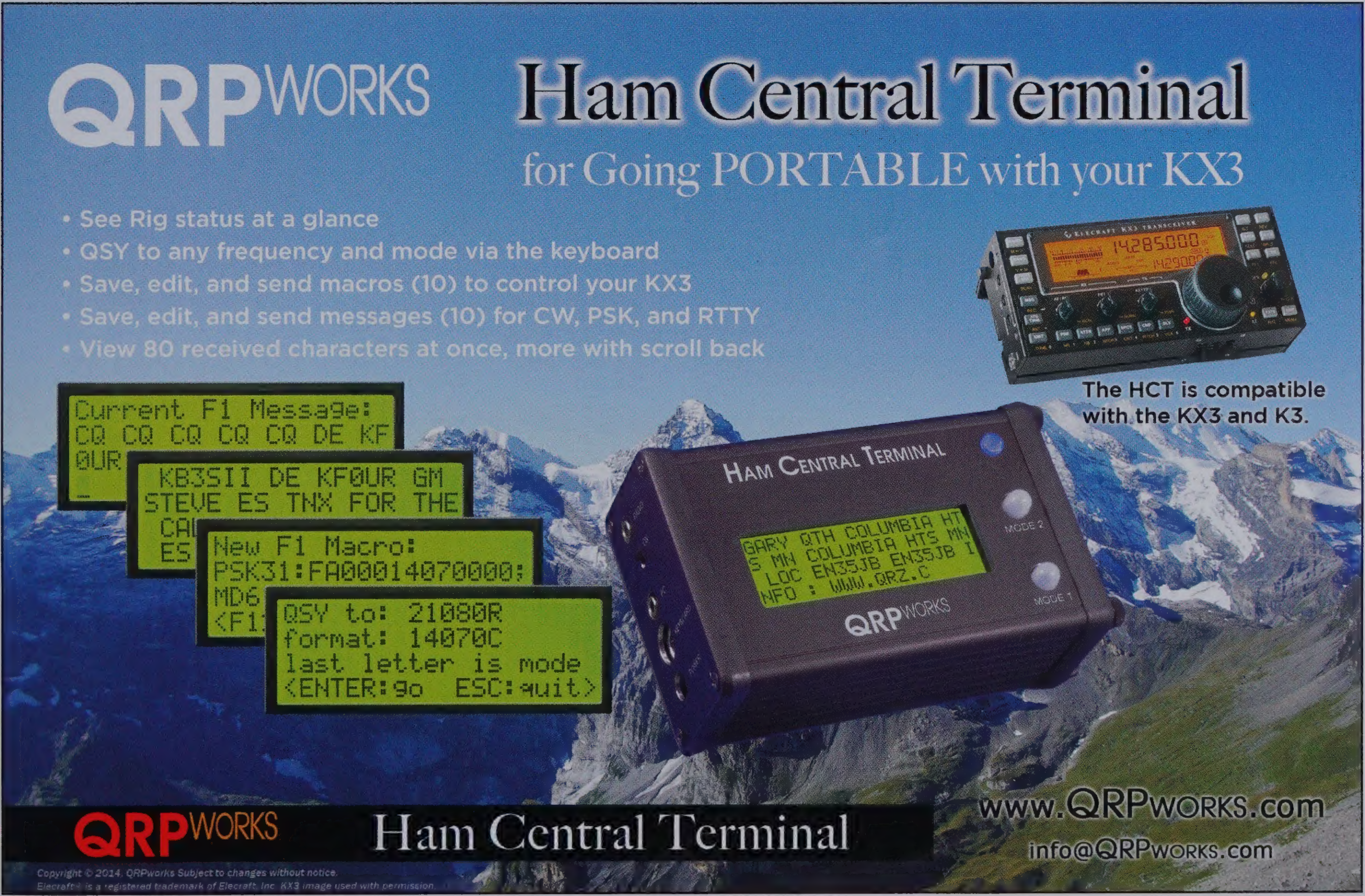
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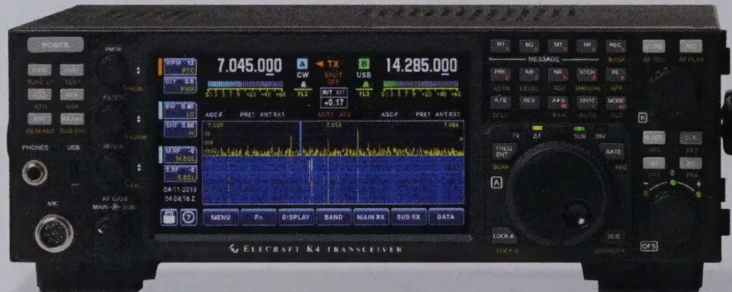

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